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CHARACTERIZATION OF EA9396 EPOXY RESIN FOR COMPOSITE REPAIR APPLICATIONS

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A program was completed to develop material property data for an epoxy resin system for aircraft repair applications. The epoxy resin was developed by Hysol and is designated EA9396. An extensive array of mechanical property data was generated for both glass and graphite reinforced laminates. Comparative properties of three resin lots were obtained. The effect of several processing and environmental variables on laminate properties was determined and the effect of long-term storage was established.

All laminates prepared and tested during this program were cured with vacuum-bag pressure only. Mechanical tests were carried out at temperatures ranging from -65°F to 200°F on both dry and humidity-aged specimens. Processing variables that were studied included cure time and temperature, vacuum pressure level, resin impregnation procedure, alternate bagging schemes, alternate bleeder materials, and alternate resin/reinforcement ratios. Environmental variables that were studied included, in addition to humidity-aging, elevated temperature exposure and exposure to a high-intensity heat-pulse.

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13. ABSTRACT (Concluded)

Test results indicated that the neat EA9396 resin system absorbed about 9 percent water by weight during humidity aging and that its glass-transition temperature decreased from around 176°C (349°F) to around 107°C (225°F) as a result of moisture absorption for a 200°F/45-minute cure. Storage at temperatures ranging from 72°F to 120°F for up to 24 months had no adverse effect on achievable interlaminar shear strength. Pot/work life of the resin was only slightly shorter after 18 months than it was for fresh resin and exceeded 90 minutes at 72°F and 40 minutes at 100°F. Mechanical properties were very consistent from batch-to-batch. The absorption of moisture significantly lowered most mechanical properties, particularly with glass reinforcement.

14. SUBJECT TERMS (Concluded)

Epoxy	Tg	Glass
Two-Part	Bearing	Graphite
Repair	Dry	Elevated Temperature
Composite	Wet	Vacuum Bag
Wet Layup	Storage Life	Humidity Aging
Properties	Pot Life	Processing
Mechanical	Laminate	Temperature
Physical	Honeycomb	Pressure
Tensile	Sandwich	Thermal Flash
Compressive	Reinforcement	Cure
Shear		

PREFACE

This report covers the work performed during the period from November 1988 to May 1991 under Air Force Contract Nos. F33615-86-C-5031 and F33615-89-C-5643, Project 7381. The work was administered under the direction of the Systems Support Division of the Air Force Materials Directorate, Wright Laboratory, Wright-Patterson Air Force Base, Ohio. Mr. William Purcell (WL/MLSE) was the Program Project Engineer.

The Principal Investigator on this program was D. Robert Askins. The major portion of the laboratory work was conducted by Messrs. L. Dee Pike, Jr., Gary Andrews, and Don Byrge.

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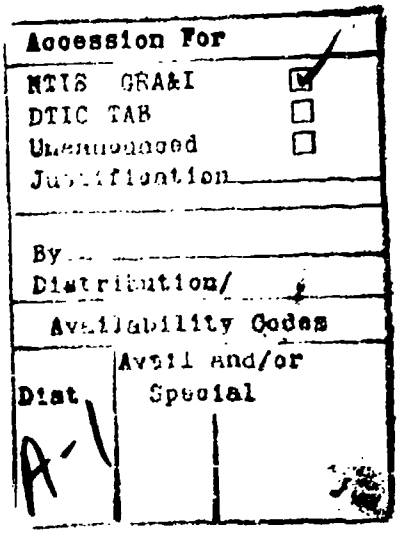


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SECTION 1
INTRODUCTION

With the increased application of fiber-reinforced, resin-matrix composite materials in aircraft structure, the need for effective repair materials and procedures has led to a great deal of activity over the past 5-10 years. Some of this has focused on the development of equipment and procedures for repair while others have resulted in the development of new materials for use in repair.

Because of limitations in available equipment and the need for rapid turnaround in field repair scenarios, the techniques and materials used in repair differ from those employed in original construction. These considerations imposed a number of constraints on both the materials and procedures employed in this program. Some of these include, but are not limited to, the following:

- The material should have a long storage life at ambient temperatures ranging up to 120°F. This generally precludes the use of prepreg material and leads to two-part resin systems.
- The material should be curable at temperatures below the boiling point of water. This is desired so that any residual moisture absorbed in the substrate to which the repair is being applied does not catastrophically volatilize during cure and cause blistering, debonding, or excessive bondline porosity.
- The material should have a reasonably long pot life (approximately 1 hour) while being curable in a relatively short period (1 hour or less).
- The material should not lose a large proportion of its mechanical strength under hot/wet conditions.
- Only vacuum pressure will be available to provide compaction during cure.

An initial series of materials screening tests were carried out on several candidate materials that were identified by a review of vendor literature and direct vendor contact. The result of that screening test effort was a selection of one material for more comprehensive characterization. The investigation reported here dealt with the characterization of that material. The goal of this work was to develop a mechanical and physical property database for EA9396 glass and graphite fabricate laminates that would enable aircraft repairs to be designed using these materials.

SECTION 2
APPROACH

The materials used during this investigation are described in Section 2.1. Section 2.2 discusses and describes the mechanical and physical test methods that were employed and the experimental design that was followed. Section 2.3 discusses the processing procedures employed to fabricate both the baseline laminates, which represented the bulk of the panels, as well as those fabricated by procedures that varied from the baseline process.

2.1 MATERIALS

The principal material of interest in the investigation reported here was a wet-layup epoxy resin manufactured by Dexter-Hysol designated EA9396. This is an unfilled, low viscosity, two-part system. It was obtained in both gallon and quart kit forms directly from Dexter-Hysol. Three different batches of EA9396, produced in August, September and October of 1988, respectively, were supplied. The baseline property measurements (to be discussed in Section 2.2) employed all three of these resin batches in order to generate batch-to-batch comparisons. In addition to the baseline properties, many supplemental tests were also performed to assess the effects of various processing, reinforcement, and environmental variables on resulting properties. Batch-to-batch comparisons were not generated for these supplemental tests. Rather, these tests employed resin from only one of the three batches.

Laminate mechanical properties were generated for both glass and graphite fabric reinforced composite panels. The specific types of fabric used in these laminates are detailed in Table 1. Both of these were balanced 8-harness satin (8HS) style fabrics. The ply orientation of each laminate was such that the warp yarns of every ply ran in the same direction. Since 8HS fabric has a "top" side that consists of predominantly one yarn direction, and a "bottom" side that consists predominantly of the perpendicular yarn direction, the up/down orientation of the plies was reversed at the laminate midplane so that all plies above the midplane were oriented in the "up" direction while all plies below the midplane were oriented "down." In the data tables to follow in this report the "warp" direction is synonymous with the longitudinal or 0° direction, while the "fill" direction is synonymous with the transverse or 90° direction.

TABLE 1

GLASS AND GRAPHITE FABRIC REINFORCEMEN DESCRIPTION

Characteristic	Glass Fabric	Graphite Fabric
Fiber Type	E-Glass	Toray T300, 3K
Fiber Sizing	F-16 (Volan-A- type) 538 (Silane type)	UC 309 (epoxy compatible)
Weave Style	7781	W133 (8HS)
Fabric Width	100 cm (39.5 in)	107 cm (42 in)
Fabric Weight	295 gm/m^2 (8.7 oz/yd^2)	366 gm/m^2 (10.8 oz/yd^2)
Nominal Cured Ply Thickness	0.2 mm (0.008 in)	0.37 mm (0.0145 in)
Fiber Specific Gravity	2.54	1.78
Nominal Fiber Properties		
Tensile Strength	3445 MPa (500 Ksi)	3734 MPa (542 Ksi)
Young's Modulus	72 GPa (10.5 Msi)	235 GPa (34.1 Msi)
Elongation	4.8%	1.6%
Source	Hexcel (1) Burlington (2)	ICI Fiberite

(1) F-16 (Volan-A) sized fabric.
(2) 538 (Silane) sized fabric.

2.2 EXPERIMENTAL DESIGN

Seven different properties were measured on all three resin batches. These are referred to here as the baseline property measurements. Six of these seven were mechanical properties and the seventh was glass transition temperature. Table 2 lists the test matrix and test methods used for the baseline property measurements. This test matrix was repeated for both the glass and graphite fabric reinforcement and for each of the three resin batches. The glass transition tests were performed on unreinforced neat resin samples.

The baseline material properties derived from the test matrix presented in Table 2 provide a comprehensive database for repair design purposes. It incorporates the effects of different batches, reinforcement type, temperature, and dry-wet variables. The material properties generated from this test matrix represent the basic design needs.

In addition to the baseline properties listed in Table 2, numerous other supplemental tests were carried out to determine the effect of various processing and environmental variables on resulting properties. Only one batch of resin was used for these tests, and the results were compared to the baseline values, where appropriate, to assess the effect of the respective processing or environmental condition. Table 3 lists these supplemental, nonbaseline tests.

2.3 TEST METHODS

Nearly all of the testing conducted during this effort was performed in accordance with standard ASTM test procedures. The specific ASTM methods employed are listed in Tables 2 and 3 and are not discussed further here. The remainder of the tests were also performed in accordance with generally accepted laboratory procedures. Since, however, these are not as readily referenced as ASTM procedures, each of these non-ASTM procedures is briefly discussed in the following sections.

All specimens that were tested at other than room temperature in the dry condition were allowed to equilibrate for 20 minutes before loading was started. In order to minimize specimen dryout, testing of moisture conditioned specimens was started 4 minutes after the specimen was installed in the test fixture and the chamber door closed.

TABLE 2

TEST MATRIX FOR BATCH-TO-BATCH COMPARISONS AND BASELINE MECHANICAL PROPERTY DATA

Property	Properties Measured(1)	Test Method	Replicates Per Batch at Each Test Condition Below: Dry -65°F	Dry 72°F	Dry 200°F	Wet (2) -65°F	Wet (2) 72°F	Wet (2) 200°F
Longitudinal (Warp) Tension	F^{tu}, ε^{ult}, E^t, ν_{12}	ASTM D3039	0	5	0	0	5	0
Transverse (Fill) Tension	F^{tu}, ε^{ult}, E^t, ν_{12}	ASTM D3039	5	5	5	5	5	5
Longitudinal (Warp) Compression	F^{cu}, ε^{ult}, E^c	ASTM D3410B	0	5	0	0	5	0
Transverse (Fill) Compression	F^{cu}, ε^{ult}, E^c	ASTM D3410B	5	5	5	5	5	5
45° Tension/ Inplane Shear	F^{ipsu}, E^t, G, ν_{12}	ASTM D3518	5	5	5	5	5	5
Interlaminar Shear	F^{ils}	Four-Point Shear (3)	0	5	0	0	5	5
Glass Transition Temp.	Tg	DMA (4)		3 (5)			3 (5)	

NOTES: (1) Poisson's ratio was only measured on two specimens from each set of five in the tensile tests.
(2) Wet = tested at indicated test temperature after wet aging to saturation at 60°C (140°F)/100% R.H.
(3) See Reference 1 and Section 2.3.1.
(4) DMA = Dynamic Mechanical Analysis.
(5) Glass Transition tests are not run at 22°C (72°F). The specimens are heated from 22°C (72°F) to above Tg at a constant heating rate.

TABLE 3

SUMMARY OF SUPPLEMENTAL TESTS TO DETERMINE SPECIFIC MATERIALS PROPERTIES AND THE EFFECTS OF PROCESSING AND ENVIRONMENTAL VARIABLES ON PROPERTIES (1)

Variable of Concern	Type of Tests Conducted	Test Method
Effect of Maximum Cure Temperature on Degree of Cure	DSC (2)	
Cure Time and Temperature	Interlaminar Shear	Four-Point Shear (5)
Cure Pressure	Laminate Physical Properties and Interlaminar Shear	ASTM D3171, D792, D2584, D2734, Four-Point Shear (5)
Bearing Strength	MIL-HDBK-17B Bearing Strength	MIL-HDBK-17B
Effect of 350°F Exposure	Interlaminar Shear	Four-Point Shear (5)
Effect of Resin Content	Interlaminar Shear and Compression	Four-Point Shear (5) ASTM D3410B
Effect of Storage Time and Temperature	Interlaminar Shear Viscosity Viscosity Curing Profile DSC (2) FTIR (3) HPLC (4)	Four-Point Shear (5) ASTM D2393 Rheometrics RSA II --- --- ---
Effect of Temperature on Pot Life	Manual/Visual Assessment	N.A.
Effect of Adhesive Fillet Size on Honeycomb Sandwich	Flatwise Tension	ASTM D297

TABLE 3 (Concluded)

SUMMARY OF SUPPLEMENTAL TESTS TO DETERMINE SPECIFIC MATERIALS PROPERTIES AND THE EFFECTS OF PROCESSING AND ENVIRONMENTAL VARIABLES ON PROPERTIES (1)

Variable of Concern	Type of Tests Conducted	Test Method
Effect of Skin Processing Technique on Honeycomb Sandwich	Edgewise Compression	ASTM C364
Effect of Thermal Flash	Compression	ASTM D3410B
Effect of Alternate Impregnation and Bagging Schemes	Physical Properties	ASTM D792, D3171, D2584, D2734
Effect of A1100 Sizing on Wet-Strength Retention	Tension Inplane Shear Interlaminar Shear	ASTM D3039 ASTM D3518 Four-Point Shear (5)

NOTES:

(1) Only one resin batch used for these tests.
(2) Dynamic Scanning Calorimetry.
(3) Fourier Transform Infrared Spectroscopy.
(4) High Pressure Liquid Chromatography.
(5) See Reference 1 and Section 2.3.1.

2.3.1 Interlaminar Shear

The most common test for interlaminar shear strength of composite laminates is the short beam shear (SBS) test of ASTM D2344. While this procedure calls for specimens 6.4 mm (0.25 inch) thick, most short beam shear tests on composite materials do not meet this requirement. The specimens are more commonly only around 3.2 mm (0.125 inch) or less thick. The typical result of such a test is that while a number for apparent interlaminar shear strength is generated, the failure mode is seldom interlaminar shear. An alternative test, referred to as Four-Point Shear (FPS), has been proposed and has been demonstrated as more likely to produce true and consistent interlaminar shear failure modes (Ref. 1). As a consequence of the advantages of the FPS test over the SBS test, the FPS test was used in this investigation to generate interlaminar shear data.

The FPS test is a modified version of the flexure test described in ASTM D790, Method II, Procedure B. In order to ensure an interlaminar failure mode, however, the support span is reduced to half the span used in flexural testing. Thus, the FPS tests carried out in this investigation were conducted at support span to specimen thickness ratios of 8 to 1 for the glass reinforced specimens and 16 to 1 for the graphite reinforced specimens.

2.3.2 Glass Transition Temperature

Glass transition temperature (Tg) can be determined by means of differential scanning calorimetry (DSC), thermomechanical analysis (TMA), and dynamic mechanical analysis (DMA). In DSC, the Tg is determined from the position of the shift in the baseline on a plot of heat release vs. temperature. The Tg values obtained with DSC are consistently lower (by 20-40°C) than those obtained with either TMA or DMA. In TMA, the Tg is determined from the location of change in slope of a plot of change in specimen length vs. temperature. The Tg values obtained from TMA are usually within 0-10°C of the value obtained with DMA. In DMA, the Tg is determined from the position of the peak in either the loss modulus (E") vs. temperature curve or the tan δ vs. temperature curve. The Tg values from the tan δ curve are always higher than those from the loss modulus curve.

In this investigation the Tg values were determined on neat EA9396 cast resin samples by means of the loss modulus curve in a DMA test. The test was carried out at a heating rate of 0.5°C/min.

2.3.3 Bearing Strength

Although this test was not carried out in accordance with an ASTM standard, it was in accordance with the standard procedure for bearing strength presented in MIL-HDBK-17B (Ref. 2).

2.3.4 Viscosity

Viscosity of the uncured resin was measured in general accordance with ASTM Method D2393 using a Brookfield RVF Viscometer. All measurements were carried out at 22±2°C (72±4°F).

2.3.5 Viscosity Curing Profile

A viscosity curing profile is a continuous measure of polymer viscosity during polymerization (cure). While the procedure can be carried out for any time-temperature history, it is usually performed by heating the test sample at a constant rate until cure is complete. This procedure was used for this investigation. Resin samples were tested in a Rheometrics Solids Analyzer (RSA II) at a heating rate of 1°C/minute and a frequency of 1 Hz. The sample was contained in a parallel plate configuration and both dynamic (η') and loss (η'') viscosities were continuously recorded throughout the test. The dynamic viscosity (η') was used as an indication of the resin viscosity behavior.

2.3.6 Differential Scanning Calorimetry (DSC)

A DSC test measures the heat released by a test sample as its temperature is raised. As the sample undergoes polymerization, the heat released during the polymerization process is reflected as the area under the hump of the heat release vs. temperature curve. If a sample is only partially polymerized, only part of the heat of polymerization will be released and the area under the curve will be correspondingly reduced. Thus, the heat release during a DSC test can be used as a measure of degree of cure.

The DSC tests carried out in this investigation were performed on a DuPont 9900 instrument in accordance with generally accepted thermal analysis techniques. Sample sizes were 5 mg.

2.3.7 Fourier Transform Infrared (FTIR) Spectroscopy

FTIR spectroscopy is a widely use and standard analytical procedure that can be used to identify the presence or absence of different chemical groups. FTIR analysis in this study were performed with a Nicolet 200XD Transform Infrared Spectrometer. These tests were performed on uncured resin samples after various periods of storage to determine whether chemical changes occurred. The resin sample was simply spread onto a salt crystal for mounting in the spectrometer.

2.3.8 High Pressure Liquid Chromatography (HPLC)

HPLC is also a widely used and generally well standardized procedure that separates multicomponent formulations into their constituent parts. The separation occurs because different components have different transit times through chromatography columns. These differences arise because of differences in molecular size and relative attraction to the column packing material.

In this program, samples were prepared for HPLC analysis by dissolving in dioxane to a concentration of 1% by weight and filtering through a 0.5-micron PTFE filter to remove insolubles. The gradient profile used during the HPLC test is listed below. The flow rate during analysis was 0.5 ml/minute.

Time (minutes)	% Water	% Dioxane
1	50	50
10	50	50
40	30	70
50	30	70

The analyses were carried out on a Hewlett-Packard Model 1090 instrument with a reverse phase C-18 ZORBOX ODS column (250 x 4.6 mm) and a UV detector.

2.4 PROCESSING PROCEDURES

The "Standard" laminate processing procedure is described in detail in Appendix A, and the various "non-Standard" procedures are described in Appendix B.

We must note that this effort was not to develop or use the precise repair processing procedure that might be used in actual on-aircraft repair with these materials. Rather, a laboratory procedure was employed that was both convenient and that produced laminate quality comparable to what would be expected in repair scenarios.

All of the laminates prepared during this investigation were prepared by wet-layup hand-impregnation procedures. Most of the laminates were prepared in the same manner, by what will be referred to as the "Standard" procedure. This includes all of the baseline laminates (Table 2) and many of the supplemental laminates (Table 3). The processing procedures used for the remainder of the supplemental laminates (Table 3) differed from the "Standard" procedure in a variety of ways, depending on the particular variable being investigated. Examples of such differences include a difference in cure temperature, cure pressure, resin/reinforcement ratio, bagging scheme, or ply impregnation procedure. A detailed step-by-step description of the "standard" procedure is presented in Appendix A, along with the rationale for certain of the procedural details.

The amount of resin used to impregnate the reinforcing fabric was about 50% more than the amount remaining in the laminate after cure, with the excess bled out the top of the ply stack. The quantity of resin used to impregnate the reinforcing fabric was determined as a ratio to the amount of reinforcement being impregnated. In the case of the laminates used in this program, the resin was not apportioned equally to each ply of reinforcement. Rather, every other ply was impregnated. This approach was adopted for two reasons. First, it considerably shortened the time required to complete the wet-layup, thereby eliminating potential pot life problems. Secondly, it permitted much more resin to be distributed onto and worked into a ply. This made it much easier to uniformly spread and impregnate a ply. The alternating dry plies were laid atop each wet impregnated ply and manually tamped down so that in short order it was uniformly wetted by resin from the preceding plies. The laminates were cured in an air circulating oven for 45 minutes at 93°C (200°F) under vacuum pressure. The vacuum level applied to the vacuum bag was typically ~635 mm (25 inches) Hg.

SECTION 3
DISCUSSION OF RESULTS

As would be surmised from the tests outlined in Table 2, a very substantial quantity of mechanical property data was generated during this program. The majority of these data represent baseline tensile, compressive, inplane and interlaminar shear properties that were determined on three different resin batches. In addition to these baseline data, additional data, as outlined in Table 3, were generated on only a single resin batch for a variety of different properties and processing or environmental exposure variations.

The following sections (3.1 through 3.12) discuss these various test results item by item. In these sections, all the data presented in either tabular or graphical form represent average values. Individual specimen data are presented in Appendices C-Q.

3.1 LAMINATE PHYSICAL PROPERTIES

The physical properties of nearly every laminate fabricated during this program were determined. These included specific gravity (D792), cured ply thickness, fiber content, resin content, and void content (D2734). In the case of the glass reinforced laminates, the fiber and resin contents were determined with an ignition loss procedure (D2584), while in the case of the graphite reinforced laminates, an acid digestion procedure (D3171, procedure A) was used. Table 4 presents a summary of the laminate physical property data for all the laminates prepared with the baseline fabrication procedure. Appendix C presents individual panel data. The physical properties of laminates fabricated by procedures that deviated from the baseline processing procedure may have been different or equivalent to those listed in Table 4. depending on the nature of the processing deviation. These will be noted as appropriate in the following sections.

It is apparent from the data in Table 4 that the laminate quality produced by the standard baseline processing procedure described in Appendix A was very consistent. While the void contents of these laminates was consistently in the vicinity of 5% by volume, it must be remembered that this was for a vacuum bag cure. While no mechanical property data were generated in this program on autoclave cured laminates, some were prepared in this manner for another project and were essentially void free as a result of the positive pressure during cure instead of vacuum pressure.

TABLE 4

PHYSICAL PROPERTIES SUMMARY FOR LAMINATES PREPARED WITH BASELINE PROCESSING PROCEDURE (1)

Type of Laminate	Specific Gravity		Ply Thickness (10^{-3} inch)		Fiber Content (% by vol)		Resin Content (% by wt.)		Void Content (% by vol.)	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
T300-W133(Gr)/EA9396 (2)	1.48	0.01	15.1	0.3	55.8	1.0	33.9	1.3	4.7	0.8
"E" - 7781(Gl)/EA9396 (2)	1.91	0.03	8.5	0.2	55.0	1.5	26.6	1.4	5.0	1.1

(1) The baseline processing procedure is detailed in Appendix A.

(2) Values based on 23 baseline laminates.

3.2 BATCH-TO-BATCH MECHANICAL PROPERTY COMPARISONS

The following four subsections present and discuss the results from the batch-to-batch mechanical property comparisons in tension, compression, inplane shear, and interlaminar shear. Table 2 listed the test matrices for these tests and indicated the data that was obtained. All of the laminates used for these tests were prepared in accordance with the standard processing procedures described in Appendix A. The data from these tests are considered as the "baseline" properties and are so referred to in later sections and tables of this report.

3.2.1 Tension

Tension tests were carried out in both the longitudinal (warp) and transverse (fill) directions for both reinforcements (graphite and glass fabric) and all three resin batches. Tables 5-10 summarize the tensile data from the baseline tests. While it is evident from the data in these tables that there are no appreciable differences evident between the three batches of resin, the effect of temperature and moisture are very apparent.

3.2.2 Compression

Compression tests were carried out in both the longitudinal (warp) and transverse (fill) directions for both reinforcements (graphite and glass fabric) and all three resin batches. Tables 11-16 summarize the compression data from the baseline tests. As with the tensile data, it is evident that there are no appreciable differences evident between the three batches of resin.

3.2.3 Inplane Shear

Inplane shear tests were carried out on both reinforcements (graphite and glass fabric) and all three resin batches. Tables 17-20 summarize the inplane shear data from the baseline tests. As with the tensile and compression data, no appreciable batch-to-batch differences are evident in the inplane shear data.

3.2.4 Interlaminar Shear

Interlaminar shear tests were carried out on both reinforcements (graphite and glass fabric) and all three resin batches. Interlaminar shear tests, however, were not performed for as many of the test conditions as was the case for tension, compression,

TABLE 5

BASELINE LONGITUDINAL (WARP) TENSILE PROPERTIES OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
22°C (72°F), DRY	1 - Avg.	356.7	24.82	51,740	3.600	17,481	0.121
	Std. Dev.	16.6	0.58	2,140	0.084	973	---
	2 - Avg.	368.5	25.37	53,440	3.680	18,512	0.110
	Std. Dev.	23.5	0.61	3,410	0.088	2,039	---
	3 - Avg.	345.4	24.70	50,090	3.583	17,238	0.114
	Std. Dev.	5.2	0.56	750	0.081	559	---
22°C (72°F), WET (2)	1 - Avg.	113.1	21.94	16,400	3.182	5,283	0.073(3)
	Std. Dev.	5.6	0.66	810	0.095	438	0.012
	2 - Avg.	106.3	22.57	15,420	3.273	4,795	0.092
	Std. Dev.	9.2	0.46	1,330	0.067	484	---
	3 - Avg.	119.5	23.70	17,330	3.437	5,213	0.092
	Std. Dev.	6.7	0.42	970	0.061	328	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.

TABLE 6

BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
-54°C (-65°F) DRY	1 - Avg.	526.4	29.25	76,350	4.243	23,133+(2)	0.153
	Std. Dev.	19.9	0.30	2,890	0.043	3,304	---
	2 - Avg.	476.8	28.99	69,150	4.205	18,159+(2)	0.155(3)
	Std. Dev.	69.2	1.81	10,040	0.263	4,975	0.22
	3 - Avg.	484.8	28.36	70,320	4.113	20,419+(2)	0.155
	Std. Dev.	7.6	0.83	1,100	0.120	6,511	---
22°C (72°F), DRY	1 - Avg.	367.8	27.04	53,340	3.922	17,052	0.124
	Std. Dev.	32.8	1.33	4,750	0.193	1,489	---
	2 - Avg.	368.1	24.42	53,390	3.542	18,450	0.128
	Std. Dev.	16.8	0.67	2,430	0.097	1,324	---
	3 - Avg.	386.7	24.44	56,080	3.545	20,766+(2)	0.130
	Std. Dev.	14.2	0.70	2,060	0.102	2,945	---
93°C (200°F) DRY	1 - Avg.	321.0	24.46	46,550	3.547	15,198	0.116
	Std. Dev.	18.3	0.68	2,660	0.099	824	---
	2 - Avg.	312.2	24.24	45,280	3.515	14,895	0.095
	Std. Dev.	12.6	0.68	1,830	0.099	551	---
	3 - Avg.	301.9	24.25	43,790	3.517	13,005+(2)	0.094
	Std. Dev.	29.2	0.80	4,230	0.116	2,268	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. Where + sign follows an average value, strain gage failed before specimen fracture on one or more specimens.
3. Average of three specimens.

TABLE 7

BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
-54°C (-65°F) WET	1 - Avg.	134.7	26.75	19,530	3.880	5,549	0.143
	Std. Dev.	19.2	0.54	2,780	0.078	1,037	---
	2 - Avg.	156.6	25.95	22,720	3.764	6,829	0.117
	Std. Dev.	15.4	1.42	2,230	0.206	460	---
	3 - Avg.	147.5	26.03	21,390	3.775	6,349	0.145
	Std. Dev.	14.7	0.66	2,130	0.095	656	---
22°C (72°F), WET	1 - Avg.	129.3	22.49	18,750	3.262	6,063	0.097
	Std. Dev.	7.3	0.62	1,060	0.090	322	---
	2 - Avg.	112.7	22.07	16,350	3.201(3)	5,292(3)	0.016
	Std. Dev.	4.4	0.78	640	0.113	226	---
	3 - Avg.	120.9	22.01	17,530	3.192	5,773	0.086
	Std. Dev.	10.9	0.23	1,580	0.033	483	---
93°C (200°F) WET	1 - Avg.	93.8	19.80	13,610	2.872	4,625	0.048
	Std. Dev.	4.0	0.38	580	0.055	148	---
	2 - Avg.	93.2	22.32	13,520	3.237	4,298	0.101
	Std. Dev.	9.1	2.83	1,320	0.411	710	---
	3 - Avg.	93.1	20.08	13,500	2.912	4,486	0.087
	Std. Dev.	7.2	2.65	1,040	0.385	430	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.

TABLE 8

BASELINE LONGITUDINAL (WARP) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
22°C (72°F), DRY	1 - Avg.	567.4	57.78	82,300	8.380	8,911	0.053
	Std. Dev.	32.5	2.60	4,710	0.377	568	---
	2 - Avg.	561.0	56.43	81,370	8.184	7,507	0.053(3)
	Std. Dev.	29.7	2.39	4,310	0.346	835	0.013
	3 - Avg.	539.4	59.03	78,230	8.562	7,060	0.073
	Std. Dev.	44.1	2.83	6,400	0.410	1,020	---
22°C (72°F), WET (2)	1 - Avg.	597.6	62.40	86,670	9.050	9,618	0.029
	Std. Dev.	40.2	1.46	5,830	0.212	603	---
	2 - Avg.	562.3	59.58	81,560	8.642	9,277	0.041
	Std. Dev.	34.2	1.62	4,960	0.235	472	---
	3 - Avg.	596.3	60.52	86,480	8.777	9,831	0.041
	Std. Dev.	23.2	1.94	3,370	0.282	365	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.

TABLE 9

BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
-54°C(-65°F) DRY	1 - Avg.	642.5	62.79	93,190	9.107	10,239	0.060(2)
	Std. Dev.	30.8	0.30	4,460	0.043	395	0.008
	2 - Avg.	619.4	63.63	89,830	9.229	9,283	0.048
	Std. Dev.	66.8	4.62	9,690	0.670	530	---
	3 - Avg.	611.4	65.77	88,680	9.540	9,208	0.053
	Std. Dev.	20.1	1.94	2,910	0.281	428	---
22°C (72°F), DRY	1 - Avg.	663.8	57.07	96,280	8.278	11,157	0.048(2)
	Std. Dev.	26.0	1.78	3,770	0.258	493	0.001
	2 - Avg.	687.1	60.60	99,660(2)	8.790(2)	11,228(2)	0.063(2)
	Std. Dev.	12.7	1.37	1,840	0.199	355	0.009
	3 - Avg.	619.1	61.96	89,800(3)	8.987(3)	9,431(3)	0.044(4)
	Std. Dev.	10.9	0.23	1,580	0.033	1,136	---
93°C (200°F) DRY	1 - Avg.	455.3	57.23	66,030	8.301	7,827	0.037
	Std. Dev.	37.3	2.67	5,410	0.387	785	---
	2 - Avg.	539.0	59.27	78,170	8.596	8,940	0.053
	Std. Dev.	70.5	2.92	10,230	0.424	992	---
	3 - Avg.	567.1	62.30	82,250	9.038	8,993	0.082
	Std. Dev.	36.8	0.90	5,340	0.130	494	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. Average of three specimens.
3. Average of four specimens.
4. Single specimen.

TABLE 10

BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10^6 psi)		
-54°C(-65°F) WET	1 - Avg.	671.3	64.70	97,370	9.384	9,760	0.046
	Std. Dev.	30.0	2.54	4,350	0.369	1,540	---
	2 - Avg.	650.7	65.57	94,380	9.510	9,662	0.046
	Std. Dev.	58.8	1.05	8,530	0.153	1,017	---
	3 - Avg.	677.2	66.60	98,220	9.659	10,058	0.068
	Std. Dev.	50.2	3.28	7,280	0.475	459	---
22°C (72°F), WET	1 - Avg.	572.2	59.48	82,990	8.627	9,526	0.037
	Std. Dev.	72.5	1.81	10,520	0.262	972	---
	2 - Avg.	619.6	60.63	89,860	8.794	10,264	0.046
	Std. Dev.	48.8	4.04	7,080	0.586	872	---
	3 - Avg.	619.1	60.54	89,790	8.780	10,286	0.056
	Std. Dev.	38.7	1.36	5,620	0.197	657	---
93°C (200°F) WET	1 - Avg.	448.2	54.85	65,010	7.956	7,058	0.034(3)
	Std. Dev.	41.2	4.85	5,980	0.703	2,348	0.018
	2 - Avg.	434.9	55.72	63,080	8.082	8,164	0.049(4)
	Std. Dev.	16.1	4.83	2,340	0.701	1,556	0.010
	3 - Avg.	445.8	54.63	64,660(5)	7.923(5)	6,979(5)	0.067(3)
	Std. Dev.	28.7	4.02	4,160	0.583	1,308	0.018

NOTES:
1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.
4. Average of four specimens.
5. Average of fix specimens.

TABLE 11

BASELINE LONGITUDINAL (WARP) COMPRESSIVE PROPERTIES
OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
22°C (72°F), DRY	1 - Avg.	336.5	25.06	48,800	3.635	15,086
	Std. Dev.	25.8	2.30	3,740	0.334	2,573
	2 - Avg.	343.4	25.68	49,800	3.724	13,359
	Std. Dev.	23.7	1.36	3,440	0.197	1,198
	3 - Avg.	346.9	25.45	50,310	3.691	15,600
	Std. Dev.	9.9	0.83	1,430	0.120	926
22°C (72°F), WET (2)	1 - Avg.	163.9	21.17	23,770	3.070	8,540
	Std. Dev.	27.4	2.05	3,970	0.298	1,300
	3 - Avg.	175.5	23.57	25,450	3.419	7,742
	Std. Dev.	13.0	2.41	1,880	0.350	1,864
93°C (200°F), WET (3)	2 - Avg.	95.6	95.56	13,860	3.049	5,229
	Std. Dev.	11.4	1.39	1,660	0.202	896

NOTES:

1. All average values represent five specimens.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Tested at incorrect temperature. Should have been tested at 22°C (72°F).

TABLE 12

BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
-54°C (-65°F), DRY	1 - Avg.	442.2	27.67	64,140	4.013	17,511
	Std. Dev.	32.1	0.68	4,650	0.099	1,004
	2 - Avg.	397.0	28.87	57,580	4.187	14,622
	Std. Dev.	9.8	2.39	1,420	0.346	953
	3 - Avg.	480.9	29.99	69,750	4.350	18,121
	Std. Dev.	26.2	0.63	3,800	0.092	1,761
22°C (72°F), DRY	1 - Avg.	287.4	26.12	41,690	3.788	11,670
	Std. Dev.	23.6	0.95	3,420	0.138	2,118
	2 - Avg.	269.4	24.75	39,080	3.590	11,725
	Std. Dev.	20.8	1.34	3,020	0.195	2,050
	3 - Avg.	287.9	24.80	41,760	3.597	12,246
	Std. Dev.	18.3	2.41	2,660	0.349	3,323
93°C (200°F), DRY	1 - Avg.	192.7(2)	23.93(2)	27,950(2)	3.471(2)	9,240(2)
	Std. Dev.	---	---	---	---	---
	2 - Avg.	172.6	23.12	25,040	3.353	7,450
	Std. Dev.	11.1	1.91	1,610	0.277	1,077
	3 - Avg.	230.5	24.97	33,430	3.622	9,625
	Std. Dev.	16.5	1.56	2,390	0.226	1,876

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. Average of two specimens.

TABLE 13

BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
-54°C (-65°F), WET	1 - Avg.	319.5	28.38	46,340	4.116	12,196
	Std. Dev.	29.6	1.06	4,300	0.154	1,686
	2 - Avg.	297.8	26.75	43,190	3.881	11,330
	Std. Dev.	27.1	2.36	3,930	0.342	1,090
	3 - Avg.	344.7	29.14	49,990	4.227	13,633
	Std. Dev.	24.8	1.48	3,600	0.215	1,424
22°C (72°F), WET	1 - Avg.	147.8	22.82	21,440	3.310	7,384
	Std. Dev.	16.8	0.40	2,430	0.058	1,929
	3 - Avg.	177.1	24.93	25,680	3.616	8,214
	Std. Dev.	12.7	3.72	1,840	0.539	815
93°C (200°F), WET	1 - Avg.	95.5	22.31	13,850	3.236	4,493
	Std. Dev.	7.6	2.23	1,100	0.323	521
	2 - Avg.	91.4	19.33	13,260	2.803	4,809
	Std. Dev.	11.7	2.73	1,700	0.396	1,335
	2 - Avg.(4)	88.3	14.35	12,800	3.060	4,156
	Std. Dev.(4)	6.9	2.12	680	0.308	836
	3 - Avg.	119.8	22.57	17,370(3)	3.273(3)	4,727(3)
	Std. Dev.	7.0	4.21	1,020	0.610	1,459

NOTES:
1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of four specimens.
4. Tested inadvertently at 93°C (200°F) WET condition. Should have been tested at 22°C (72°F) WET condition.

TABLE 14

BASELINE LONGITUDINAL (WARP) COMPRESSIVE PROPERTIES
OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
22°C (72°F), DRY	1 - Avg.	456.9(3)	52.88(3)	66,270(3)	7.670(3)	9,627(3)
	Std. Dev.	65.3	7.99	9,470	1.159	2,860
	2 - Avg.	496.8	60.23	72,060	8.735	8,062
	Std. Dev.	33.2	7.83	4,810	1.135	1,534
	3 - Avg.	481.8(4)	57.18(4)	69,880(4)	8.290(4)	9,532+(4,5)
	Std. Dev.	21.0	11.79	3,050	1.711	3,334
22°C (72°F), WET (2)	1 - Avg.	396.5	51.71	57,510	7.502	8,313
	Std. Dev.	61.4	4.07	8,910	0.590	2,664
	2 - Avg.	369.9	54.87	53,650	7.958	7,397
	Std. Dev.	20.8	8.27	3,010	1.200	1,794
	3 - Avg.	347.6	52.78	50,410	7.655	7,807
	Std. Dev.	14.8	9.39	2,150	1.362	2,045

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F), 100% R.H. until saturated.
3. Average of three specimens.
4. Average of four specimens.
5. Where + sign follows an average value, strain gage failed before specimen fracture on one or more specimens.

TABLE 15

BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
-54°C(-65°F), DRY	1 - Avg.	592.5	69.49(2)	85,930	9.499(2)	9,993(2)
	Std. Dev.	32.7	7.78	4,740	1.128	1,680
	2 - Avg.	531.0	56.09(2)	77,010	8.135(2)	11,615(2)
	Std. Dev.	41.6	3.26	6,030	0.473	2,264
	3 - Avg.	596.5	54.38	86,520	7.887	13,047
	Std. Dev.	43.7	2.96	6,340	0.429	888
22°C (72°F), DRY	1 - Avg.	414.2	51.51	60,080	7.471	7,919
	Std. Dev.	32.3	6.83	4,680	0.990	872
	2 - Avg.	410.1(2)	57.38(2)	59,480(2)	8.322(2)	8,148(2)
	Std. Dev.	37.3	5.08	5,410	0.737	1,714
	3 - Avg.	434.6	54.34	63,030	7.882	8,698
	Std. Dev.	20.8	4.72	3,010	0.685	3,423
93°C (200°F), DRY	1 - Avg.	300.2	55.93	43,540	8.112	5,342
	Std. Dev.	10.7	5.24	1,550	0.760	1,055
	2 - Avg.	257.1	56.29	37,290	8.164	4,511
	Std. Dev.	16.5	9.18	2,400	1.331	980
	3 - Avg.	279.1	52.22	40,480	7.574	6,217
	Std. Dev.	11.3	1.88	1,640	0.273	853

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. Average of four specimens.

TABLE 16

BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10^{-6})
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10^6 psi)	
-54°C(-65°F), WET	1 - Avg.	544.1	63.28	78,920	9.179	10,090
	Std. Dev.	34.1	4.64	4,950	0.673	2,806
	2 - Avg.	514.1	59.32	74,560	8.604	10,476
	Std. Dev.	31.5	1.42	4,570	0.206	1,383
	3 - Avg.	534.3	59.32	77,500	8.604	9,337
	Std. Dev.	51.4	3.14	7,460	0.456	2,256
22°C (72°F), WET	1 - Avg.	365.8	61.49	53,060	8.918	5,893
	Std. Dev.	32.3	1.91	4,680	0.277	848
	2 - Avg.	338.3	53.43	49,070	7.749	7,366
	Std. Dev.	12.1	7.74	1,760	1.123	3,156
	3 - Avg.	344.6	55.50	49,980	8.049	6,754
	Std. Dev.	32.3	3.55	4,690	0.515	1,256
93°C (200°F), WET	1 - Avg.	168.0(3)	66.89(3)	24,370(3)	9.701(3)	2,485(3)
	Std. Dev.	21.9	5.58	3,170	0.810	421
	2 - Avg.	190.4	56.16	27,610	8.146	3,783
	Std. Dev.	33.9	4.72	4,910	0.685	1,064
	3 - Avg.	222.3(3)	58.57(3)	32,240(3)	8.495(3)	3,950(3)
	Std. Dev.	23.4	6.29	3,400	0.912	704

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F), 100% R.H. until saturated.
3. Average of four specimens.

TABLE 17

BASELINE IN-PLANE SHEAR PROPERTIES OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			±45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	±45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10^6 psi)	±45° Tens. Modulus (10^6 psi)	
-54°C(-65°F), DRY	1 - Avg.	114.9(2)	7.39	20.95	16,670(2)	1.072(2)	3.038(2)	0.418(2)
	Std.Dev.	19.4	0.83	2.23	2,820	0.120	0.323	0.033
	2 - Avg.	118.3(3)	6.93(3)	19.71(3)	17,160(3)	1.005(3)	2.858(3)	0.420(3)
	Std.Dev.	15.9	0.75	2.48	2,300	0.109	0.360	0.036
	3 - Avg.	115.6	7.01	19.62	16,770	1.016	2.845	0.397
	Std.Dev.	16.0	0.68	2.45	2,320	0.098	0.356	0.043
22°C (72°F), DRY	1 - Avg.	78.2(2)	5.94(2)	17.25(2)	11,340(2)	0.861(2)	2.502(2)	0.449(2)
	Std.Dev.	9.9	0.38	1.21	1,430	0.055	0.176	0.029
	2 - Avg.	80.7(4)	4.99(4)	14.28(4)	11,710(4)	0.723(4)	2.071(4)	0.433(4)
	Std.Dev.	4.5	0.46	1.40	810	0.066	0.203	0.079
	3 - Avg.	76.9	4.91	13.86	11,150	0.712	2.010	0.411
	Std.Dev.	7.2	0.32	1.14	1,050	0.047	0.166	0.037
93°C (200°F) DRY	1 - Avg.	48.7(2)	3.08(2)	10.23(2)	7,060(2)	0.446(2)	1.484(2)	0.676(2)
	Std.Dev.	9.2	0.54	1.50	1,330	0.079	0.217	0.087
	2 - Avg.	47.9(2)	3.09(2)	9.73(2)	6,940(2)	0.448(2)	1.411(2)	0.577(2)
	Std.Dev.	5.4	0.24	0.80	790	0.035	0.116	0.091
	3 - Avg.	51.2	3.38	11.01	7,420	0.490	1.597	0.631
	Std.Dev.	9.5	0.37	1.17	1,380	0.054	0.169	0.047

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. Average of seven specimens.
3. Average of six specimens.
4. Average of eleven specimens.

TABLE 18

BASELINE IN-PLANE SHEAR PROPERTIES OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			±45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	±45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10^6 psi)	±45° Tens. Modulus (10^6 psi)	
-54°C(-65°F), WET	1 - Avg.	60.3(3)	6.41(3)	18.91(3)	8,740(3)	0.930(3)	2.743(3)	0.476(3)
	Std.Dev.	9.5	0.24	0.79	1,380	0.035	0.115	0.051
	2 - Avg.	57.7	5.30	15.89	8,370	0.769	2.305	0.508
	Std.Dev.	7.3	0.68	1.14	1,060	0.099	0.166	0.096
	3 - Avg.	57.3	6.01	18.01	8,310	0.873	2.612	0.498
	Std.Dev.	6.0	0.64	1.83	870	0.093	0.266	0.022
22°C (72°F), WET	1 - Avg.	37.0(3)	3.30(3)	10.60(3)	5,370(3)	0.479(3)	1.537(3)	0.610(3)
	Std.Dev.	5.1	0.34	1.09	740	0.050	0.158	0.121
	2 - Avg.	37.9	3.04	9.63	5,490	0.441	1.396	0.608
	Std.Dev.	2.8	0.66	1.32	400	0.096	0.192	0.150
	3 - Avg.	39.1	3.84	12.77	5,670	0.557	1.852	0.672
	Std.Dev.	5.4	0.52	1.68	790	0.076	0.244	0.172
93°C (200°F) WET	1 - Avg.	18.7(4)	1.61(4)	5.58(4)	2,710(4)	0.234(4)	0.809(4)	0.775(4)
	Std.Dev.	3.3	0.42	0.84	480	0.061	0.122	0.237
	2 - Avg.	19.3	1.34	4.87	2.800	0.194	0.706	0.840
	Std.Dev.	0.9	0.28	0.86	130	0.041	0.125	0.217
	3 - Avg.	18.6	2.08	7.52	2,700	0.301	1.091	0.835
	Std.Dev.	2.6	0.72	2.23	370	0.104	0.323	0.120

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of eight specimens.
4. Average of seven specimens.

TABLE 19

BASELINE IN-PLANE SHEAR PROPERTIES OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			±45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	±45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10^6 psi)	±45° Tens. Modulus (10^6 psi)	
-54°C(-65°F), DRY	1 - Avg.	125.1	5.50	18.91	18,140	0.797	2.742	0.723
	Std.Dev.	16.8	0.67	2.00	2,440	0.097	0.290	0.052
	2 - Avg.	120.5	5.79	19.38	17,480	0.839	2.811	0.674
	Std.Dev.	8.8	0.53	1.85	1,270	0.077	0.269	0.037
	3 - Avg.	134.8	5.86	20.31	19,550	0.850	2.945	0.731
	Std.Dev.	4.3	0.34	1.61	620	0.050	0.233	0.056
22°C (72°F), DRY	1 - Avg.	89.3	3.99	14.30	12,950	0.579	2.074	0.791
	Std.Dev.	9.8	0.57	2.13	1,420	0.083	0.309	0.060
	2 - Avg.	81.9	4.28	14.67	11,880	0.621	2.128	0.721
	Std.Dev.	3.4	0.44	0.96	500	0.064	0.140	0.087
	3 - Avg.	93.9	4.43	15.25	13,620	0.642	2.211	0.724
	Std.Dev.	8.5	0.32	1.43	1,230	0.047	0.208	0.147
93°C (200°F) DRY	1 - Avg.	53.5	2.62	9.92	7,760	0.380	1.439	0.894
	Std.Dev.	7.4	0.21	0.84	1,080	0.031	0.122	0.053
	2 - Avg.	52.6	3.18	11.34	7,630	0.461	1.645	0.799
	Std.Dev.	3.7	0.68	1.93	540	0.098	0.280	0.093
	3 - Avg.	55.6	2.74	10.12	8,060	0.398	1.468	0.840
	Std.Dev.	4.1	0.24	1.13	600	0.035	0.164	0.081

NOTES: 1. All average values represent five specimens unless otherwise noted.

TABLE 20

BASELINE IN-PLANE SHEAR PROPERTIES OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			±45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	±45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10^6 psi)	±45° Tens. Modulus (10^6 psi)	
-54°C(-65°F), WET	1 - Avg.	112.4	5.96	19.98	16,300	0.865	2.897	0.673
	Std.Dev.	17.4	0.19	1.60	2,520	0.028	0.232	0.093
	2 - Avg.	116.1	6.37	21.26	16,830	0.924	3.083	0.669
	Std.Dev.	10.6	0.82	2.85	1,540	0.119	0.414	0.052
	3 - Avg.	119.2	4.89	17.52	17,280	0.709	2.541	0.791
	Std.Dev.	14.8	0.43	1.79	2,140	0.063	0.260	0.070
22°C (72°F), WET	1 - Avg.	68.7	3.39	11.74	9,970	0.492	1.702	0.729
	Std.Dev.	9.3	0.31	1.10	1,350	0.045	0.159	0.083
	2 - Avg.	70.5	4.21	14.92	10,230	0.610	2.163	0.779
	Std.Dev.	9.4	0.89	3.12	1,370	0.129	0.453	0.128
	3 - Avg.	77.1	3.61	13.46	11,180	0.524	1.952	0.869
	Std.Dev.	6.7	0.41	1.29	970	0.060	0.187	0.108
93°C (200°F) WET	1 - Avg.	31.2	1.70	5.97	4,520	0.247	0.866	0.755
	Std.Dev.	4.3	0.41	1.42	630	0.059	0.206	0.124
	2 - Avg.	30.8	1.85	6.82	4,470	0.268	0.989	0.873
	Std.Dev.	3.5	0.86	2.83	500	0.124	0.410	0.186
	3 - Avg.	30.9	1.57	6.59	4,480	0.228	0.956	1.074
	Std.Dev.	3.3	0.28	0.83	480	0.040	0.120	0.142

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.

and inplane shear. Table 21 summarizes the interlaminar shear data from the baseline tests. Again, all three resin batches produced very similar property levels.

3.3 GLASS TRANSITION TEMPERATURE

As note · Section 2.3.2 and Table 2, Tg measurements were carried out on neat resin samples fo dry and wet conditions by means of a DMA test. Figure 1 illustrates a typic· MA test result, and the Tg value determined from the analysis is indicated in the fig.re. Table 22 summarizes the Tg data from the baseline tests. It is apparent from the data in Table 22 that the batch-to-batch Tg values are in excellent agreement and also that absorbed moisture significantly reduces the Tg of EA9396.

An additional Tg test was performed on a neat EA9396 resin sample that was cured at a lower temperature and for a shorter time than the standard cure condition. This value is also listed in Table 22 for comparison. The reduced Tg value for this shorter, lower temperature cure suggests that cure is incomplete and this corroborates the results from the cure studies that are discussed in Sections 3.5.1 and 3.5.2.

3.4 BEARING STRENGTH

Bearing strength tests were performed on only one of the three resin batches. All of the laminates used for bearing strength tests were prepared and cured in accordance with the standard baseline processing procedures, detailed in Appendix A. Bearing strength tests were carried out on both reinforcements (graphite and glass fabric) and in both the wet and dry condition although only at room temperature. Table 23 summarizes the bearing test data. It is evident from these data that absorbed moisture significantly reduces bearing strength.

3.5 EFFECT OF NONBASELINE CURE/PROCESSING CONDITIONS

The baseline cure condition used in this program was a vacuum bag cure at 93°C (200°F) for 45 minutes. Alternative conditions that were used included curing at both lower and higher temperatures, lower and higher cure vacuum levels than the baseline 635 mm (25 in) Hg, and cure times other than 45 minutes. Laminates processed at these alternative conditions were tested for interlaminar shear strength to assess the effect of the alternative cure. In addition, a number of differential scanning calorimetry (DSC) measurements were made for different cure temperatures and cure histories.

TABLE 21

BASELINE INTERLAMINAR SHEAR PROPERTIES OF
EA9396 COMPOSITE LAMINATES

Reinforcement Type	Resin Batch Number	Test Condition(3)	SI Units Interlaminar Shear Strength (1,2) (MPa) Avg.	SI Units Std. Dev.	U.S. Units Interlaminar Shear Strength (1,2) (psi) Avg.	U.S. Units Std. Dev.	Weight Gain During Aging (%)
"E"-7781 Glass	1	22°C(72°F) Dry	40.03	1.68	5806	244	N.A.
	2	22°C(72°F) Dry	38.27	1.22	5551	177	N.A.
	3	22°C(72°F) Dry	37.97	1.64	5507	238	N.A.
	1	22°C(72°F) Wet	18.66	0.37	2706	53	2.32
	2	22°C(72°F) Wet	20.74	0.85	3008	124	2.10
	3	22°C(72°F) Wet	22.17	0.35	3216	51	2.09
	1	93°C(200°F) Wet	9.25	0.50	1342	73	2.24
	2	93°C(200°F) Wet	13.25	0.57	1922	82	2.09
	3	93°C (200°F) Wet	12.93	0.52	1875	75	2.11
T300-W133 Graphite	1	22°C(72°F) Dry	39.06	2.78	5665	403	N.A.
	2	22°C(72°F) Dry	39.82	4.55	5776	660	N.A.
	3	22°C(72°F) Dry	38.94	2.35	5648	341	N.A.
	1	22°C(72°F) Wet	32.74	15.82	4748	409	2.19
	2	22°C(72°F) Wet	32.63	6.96	4733	180	2.32
	3	22°C(72°F) Wet	31.78	4.14	4609	107	2.24
	1	93°C(200°F) Wet	14.21	1.19	2061	173	2.22
	2	93°C(200°F) Wet	15.51	0.48	2250	69	2.32
	3	93°C (200°F) Wet	18.73	0.97	2716	140	2.24

NOTES:

1. Four-point shear. Graphite tests at 16:1 span-thickness ratio, Glass tests at 8:1.
2. Warp direction of fabric is running in length direction of specimens.
3. WET = wet aged at 60°C (140°F)/95-100% R.H. until saturated.

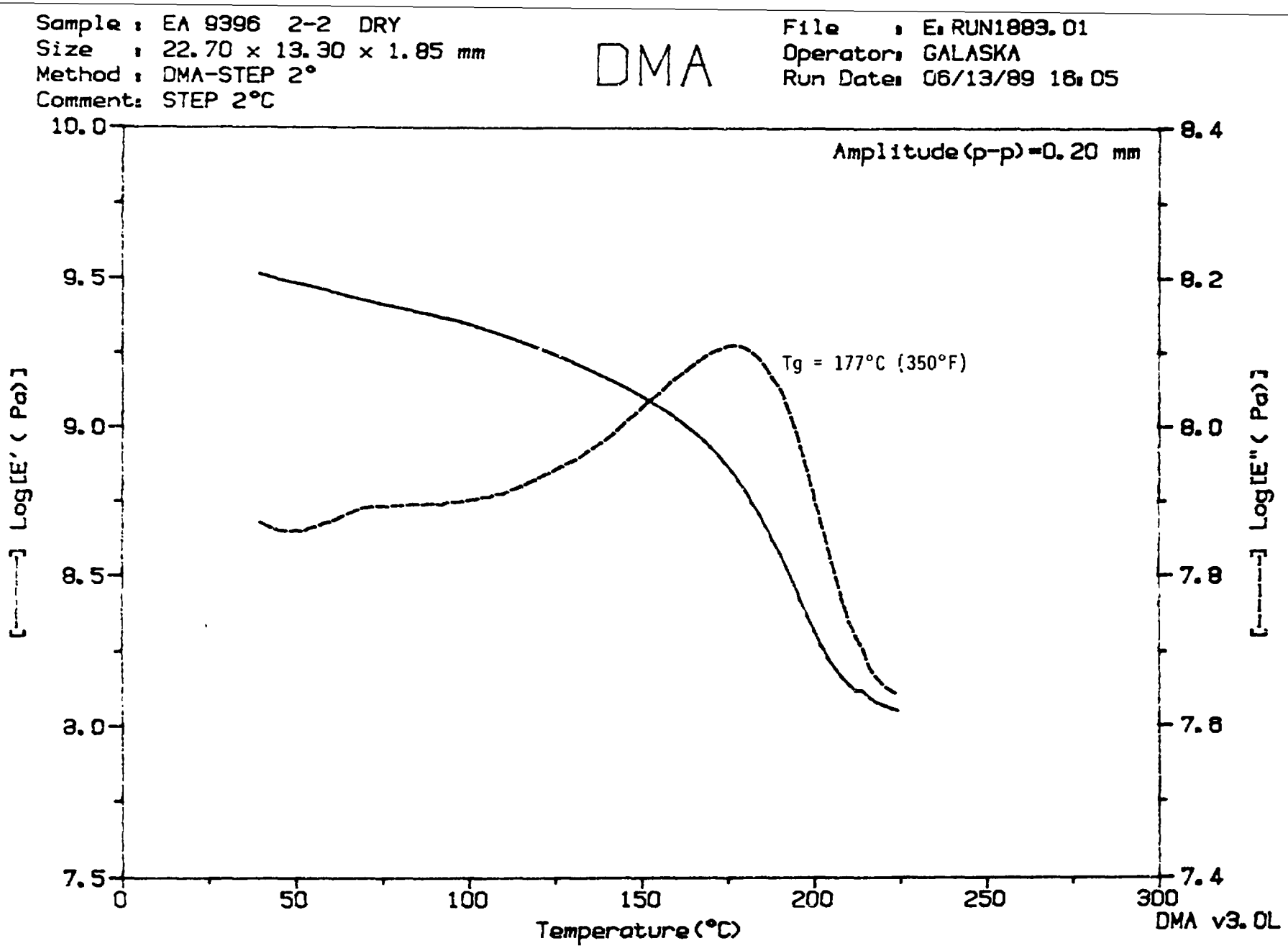


Figure 1. Typical DMA Cure With Tg Value.

TABLE 22

GLASS TRANSITION TEMPERATURE OF EA9396
NEAT RESIN CASTINGS (1)

Resin Batch Number	Test Condition	Tg (2) (°C)	(°F)	Weight Gain During Aging (%)
1 - Avg.	Dry	175	347	N.A.
2 - Avg.	Dry	176	349	N.A.
3 - Avg.	Dry	177	350	N.A.
1 - Avg.	Wet (3)	106	223	9.1
2 - Avg.	Wet (3)	108	226	8.7
3 - Avg.	Wet (3)	107	225	8.8
NA (4)	Dry	149	300	N.A.

(1) Castings cured 45 minutes at 93°C (200°F) unless otherwise noted.
(2) Listed values represent averages of three test samples from each resin batch.
(3) Wet = Aging at 60°C (140°F), 95-100% R.H. until saturated.
(4) Casting cured 30 minutes at 82°C (180°F).

TABLE 23

ROOM TEMPERATURE BEARING STRENGTH OF EA9396
COMPOSITE MATERIAL

Reinforcement	Aging Condition	Bearing Strength @ 4% Elong. (ksi)	Max. Bearing Strength (ksi)
E-7781 Glass	None(dry)	42.4	54.9
	Wet (1)	21.6	35.1
T300-W133 Graphite	None (dry)	58.3	71.3
	Wet (1)	33.7	89.0

(1) Wet aged at 60°C (140°F), 95-100% RH until saturated.

3.5.1 Effect of Cure Temperature on Degree of Cure by DSC

Both isothermal and dynamic DSC measurements were made on neat uncured EA9396 resin samples. Table 24 summarizes the data obtained from these tests. Figure 2 illustrates typical dynamic and isothermal DSC test scans. Heat released as a result of the polymerization (or cure) reaction causes the plotted curve to rise above the baseline. The area under this curve corresponds to the total heat released during the curing reaction. In the two curves illustrated in Figure 2, the total heat released was 535.1 J/gm for the case of the dynamic scan and 479.3 J/gm for the case of the isothermal scan. The higher heat release value for the dynamic test implies that the sample was more completely cured during this test than in the isothermal test. This is a logical result since the sample was heated to a substantially higher maximum temperature in the dynamic test (>200°C (>392°F)) than in the isothermal test (82°C (180°F)).

In the case of the isothermal tests, a second DSC test, carried out in the dynamic mode at 2°C/minute, was performed on each sample to determine residual exotherm. Figure 3 illustrates a dynamic DSC test result from which residual exotherm, or heat release during postcure, was obtained.

The first two tests listed in Table 24, dynamic tests at 10°C/minute and 1°C/minute, respectively, were performed to establish the total exotherm (total heat release during cure) of the EA9396 resin and to determine whether heating rate caused significant differences in exotherm. From these tests, it appears that between 535 and 574 J/gm are released by EA9396 when it is completely cured. Following these tests, four isothermal tests were carried out over the temperature range of 66-107°C (150-225°F).

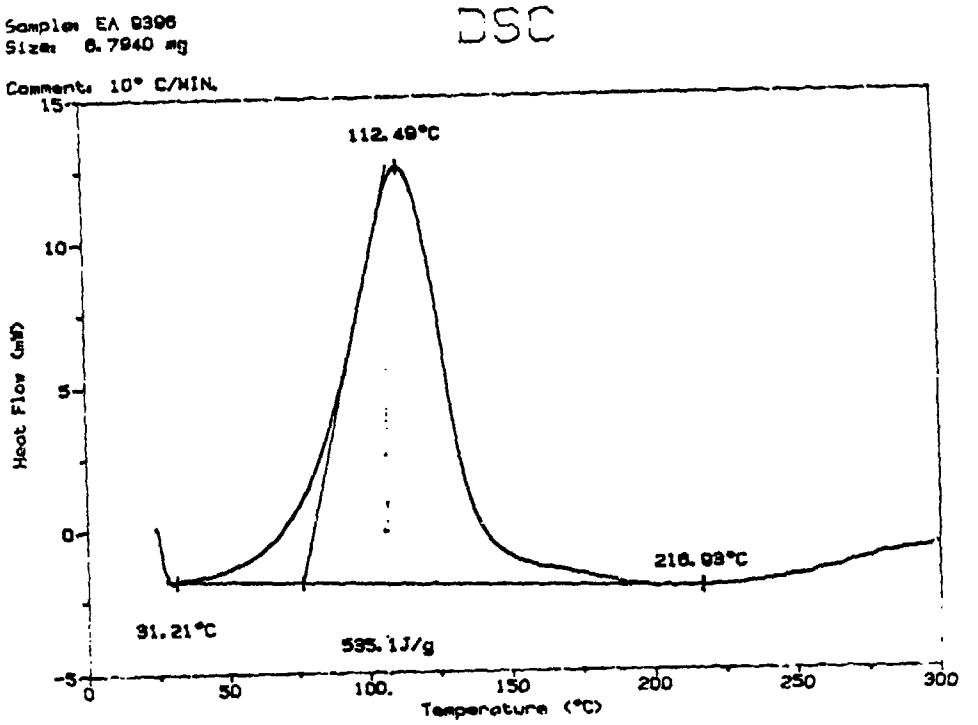
It is evident from the isothermal data that as the cure temperature increases, the degree of cure, as measured by the heat release, increases and the residual exotherm (or remaining cure that can be achieved) diminishes. Examination of the residual exotherm DSC curves are particularly interesting in that they demonstrate that the remainder of the cure still to be accomplished after the initial cure, does not begin until the temperature is considerably higher than the temperature at which the initial cure occurred. This is evident by comparing the curves in Figures 2b and 3. The data in Table 24 show that the postcure initiation temperature becomes progressively higher as the initial cure temperature is increased. Another point of interest from the data for the four isothermal tests in the center of Table 24 is that the sum of the heat released during

TABLE 24

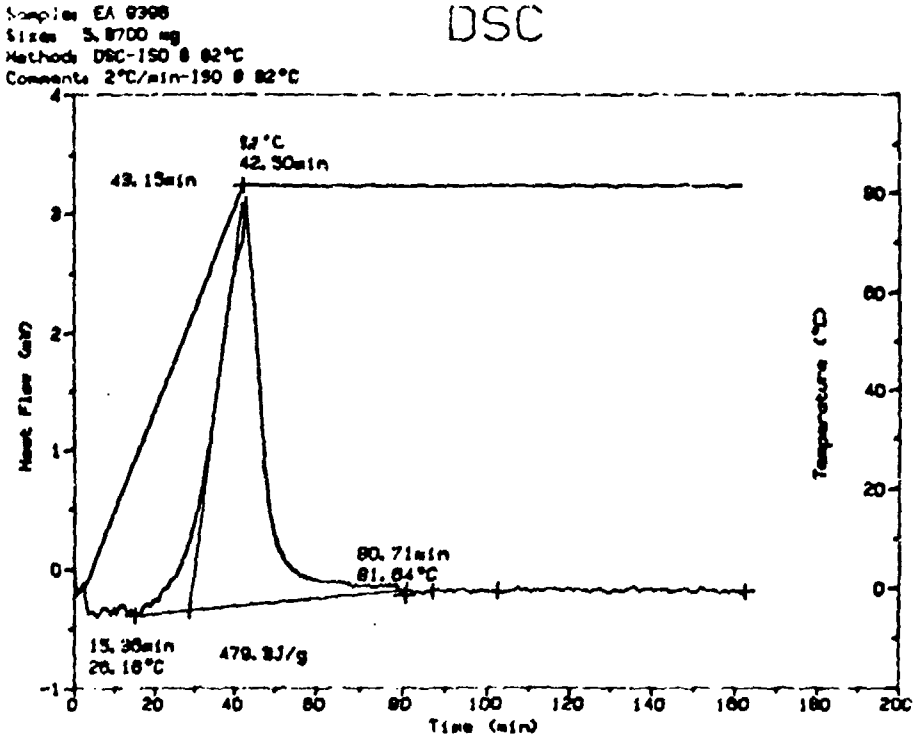
EFFECT OF TEMPERATURE ON CURE EXOTHERM BEHAVIOR
OF EA9396 NEAT RESIN

DSC Run Type	Heating Rate (°C/min)	Cure(Hold) Temperature (°C) [°F]	Time to Complete Cure at Hold Temp. (min.)(1)	Heat Release During Cure (J/gm)	Cure State (%) (2)	Heat Release During Postcure (J/gm)(3)	Temperature at Which Postcure Initiates (°C) [°F]	Total Heat Release (J/gm)
Dynamic	10	— (4)	—	535	100%	—	—	535
Dynamic	1	— (4)	—	574	100%	—	—	574
Isothermal	2	(66)[150]	~75	450	83%	94	(100)[212]	544
Isothermal	2	(82)[180]	~40	479	89%	57	(110)[230]	536
Isothermal	2	(93)[200]	~30	486	91%	46	(120)[248]	532
Isothermal	2	(107)[225]	~10	496	95%	27	(130)[266]	522
Isothermal	2	(82)[180]	~41	519	89%	60(5)	(107)[225]	579
Dynamic	10	— (4)	—	—	68%(est)(6)	170	(69)[156]	535(est)(6)

(1) Time after reaching hold temperature.
(2) Heat released during cure ÷ total heat release.
(3) All values in this column determined in a dynamic, 2°C/min, DSC test.
(4) Temperature increased throughout cure until no further heat release evident. Test typically terminated in 225-300°C range.
(5) After the 82°C isothermal cure, the sample was held at 22°C for 7 days before the residual heat (of postcure) was measured in a dynamic DSC test.
(6) Sample cured at 22°C for 7 days before residual heat (or postcure) was measured in a dynamic DSC test. Assumed a total heat release of 535 J/gm (equal to first test listed in table). Heat release during 7 day, 22°C cure assumed equal to 535 J/gm minus heat release during postcure.



(a) Dynamic DSC Heat Release Test for Curing of EA9396.



(b) Isothermal DSC Heat Release Test for Curing of EA9396 at 82°C (180°F).

Figure 2. Typical Dynamic and Isothermal Heat Release Test Results for Curing of EA9396.

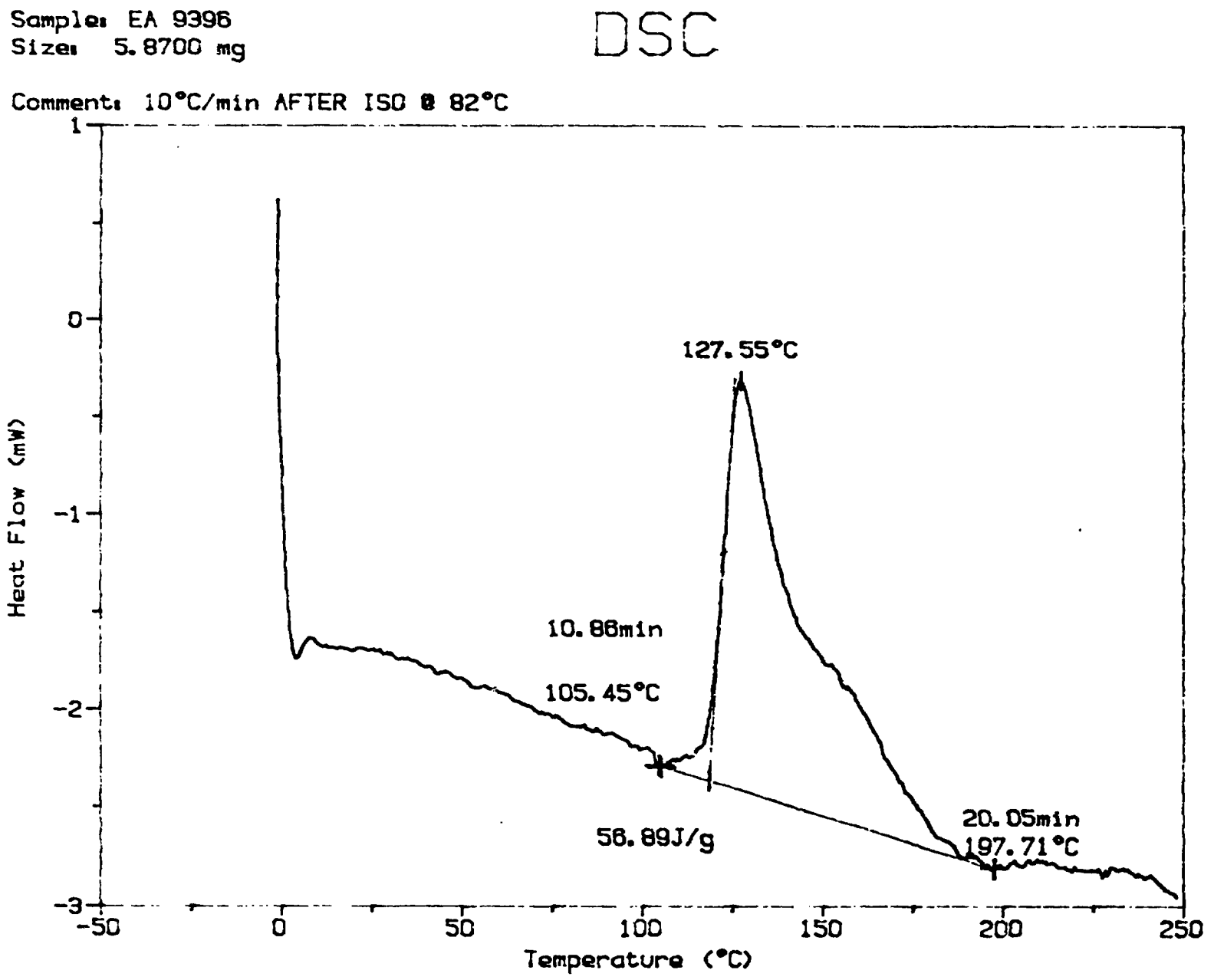


Figure 3. Dynamic DSC Residual Heat Release Test for Postcuring of EA9396 After Isothermal Cure at 82°C (180°F).

the cure and postcure ranges between 522 and 544 J/gm. These total heat release values are in excellent agreement with the total heat release values determined previously for the two dynamic tests.

The last two DSC tests that were conducted were aimed at determining:

(a) whether an 82°C (180°F) cure, followed by a 7-day postcure at room temperature, would produce full cure, and

(b) how much cure could be achieved in a 7-day cure at room temperature.

In the former instance, one would expect a dynamic residual exotherm test that was delayed 7 days after the initial 82°C (180°F) isothermal cure, to exhibit no additional heat release if cure had proceeded to completion during the intervening week at room temperature. In the latter case, the amount of residual exotherm remaining would provide a measure of how complete the cure was in the initial 7-day room temperature cure.

Note from the data in Table 24 that after an 82°C (180°F) cure, an additional 7 days at room temperature did not appear to produce any additional cure since only an additional 60 J/gm of exotherm was measured after the 7-day period.

The 7-day room temperature cure appeared to produce only about 68% of full cure since an additional 170 J/gm of exotherm was measured in a dynamic DSC test after the 7-day room temperature cure. This is consistent with the pattern observed in the other isothermal cure tests.

Based on these measurements, the baseline cure schedule of 45 minutes at 93°C (200°F) would appear to produce approximately 90% of the full cure in so far as heat release is concerned. Thus one would expect that extended subsequent exposure to temperatures above this level would drive the material to more complete cure. These results are consistent with the Tg data discussed in Section 3.3, in which a shorter, lower temperature cure produced a lower Tg than the standard cure, implying a lower degree of cure.

3.5.2 Effect of Cure Time and Temperature on Interlaminar Shear Strength

Graphite fabric reinforced laminates were impregnated and cured at various combinations of time and temperature and then tested for interlaminar shear strength. Table 25 presented the data obtained from these tests.

It is evident that for all of the cures carried out at 80°C (175°F) or higher, the room temperature dry shear strength is basically equivalent while it falls off somewhat for the reduced temperature cure. There appears to be a slight loss of wet shear strength levels for reduced cure temperatures but so long as the cure temperature remains at 80°C (175°F) or above, the loss is not much more than about 10%. The room temperature cure, on the other hand, results in a wet room temperature shear strength that is nearly 25% below that produced by the higher temperature cures.

3.5.3 Effect of Cure Vacuum Pressure on Interlaminar Shear Strength

Glass fabric reinforced laminates were impregnated and cured at the standard baseline cure condition of 45 minutes at 93°C (200°F) but at vacuum pressure levels both above and below the nominal 635 mm (25 in) Hg used with the baseline laminates. These laminates were then tested for interlaminar shear strength. Table 26 presents these test results, as well as the physical properties for each of these laminates. The physical property data show several logical trends. Specific gravity increases and ply thickness decreases with increasing cure vacuum level. The shear strength behavior appears to be independent of vacuum level until the vacuum level falls below 625 mm (25 in) Hg. At lower vacuum levels than this, the shear strength is noticeably lower. This may be, in part, a result of the fact that the void contents of the laminates cured under the reduced vacuum levels are higher than the normal 5% that occurs in the laminates cured under 635 mm (25 in) Hg vacuum.

3.6 RESIN POT/WORK LIFE

Two different types of pot-life or work-life tests were carried out. The purpose of the first was to determine the time available before a freshly mixed resin batch advanced to gel. The purpose of the second was to determine the time available before an impregnated layup advanced so far that it was no longer workable.

In the first test, two 200-gram samples of EA9396 were mixed and placed in 22°C (72°F) and 38°C (100°F) environments while pot-life observations were recorded.

TABLE 25

EFFECT OF CURE TEMPERATURE ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396 LAMINATES

Cure Condition	Interlaminar Shear Strength (psi) (2) 22°C (72°F), Dry	22°C (72°F), Wet (4)	93°C (200°F), Wet (4)
45 min. at 107°C (225°F)	6120	4540	---
45 min. at 93°C (200°F) (3)	5700	4700	2340
30 min. at 93°C (200°F)	6220	4430	2270
30 min. at 82°C (180°F)	6230	4340	1900
45 min. at 79.5°C (175°F)	5640	4020	---
7 days at 22°C (72°F) plus additional 3 mos. dry storage or wet aging	5010	3410	---

(1) All cures were under nominally full vacuum pressure ~ 25 in. Hg).
(2) Four-point shear test procedure.
(3) This represents the baseline cure schedule used throughout the program.
(4) Wet aged at 60°C (140°F), 95-100% R.H. till saturated.
(5) Laminate under compacting vacuum bag pressure only during first few hours of 22°C (72°F) cure. Remaining 164 hrs. of cure at 22°C (72°F) under ambient conditions.

TABLE 26

EFFECT OF CURE PRESSURE ON LAMINATE PHYSICAL CHARACTERISTICS AND INTERLAMINAR SHEAR STRENGTH

Cure Vacuum Level (in. Hg)	Specific Gravity	Resin Content (% wt.)	Fiber Content (% vol.)	Void Content (% vol.)	Ply Thickness (mil)	Interlaminar Shear Strength (psi) (1)
10	1.87	28.6	52.6	5.4	8.5	4640
16	1.88	25.6	55.0	7.1	8.3	5170
23	1.91	24.4	56.6	6.7	8.0	4630
25 (2)	1.91	26.6	55.2	5.1	8.0	5700
27	1.94	26.2	56.1	3.9	7.8	5940

(1) Tests conducted at 72°F on dry specimens.
(2) Baseline laminates.

These pot-life measurements were repeated on samples from the same batch of resin after 20 months of storage at 4°C (40°F). Table 27 presents the results of these tests.

In the second test, two 12-ply graphite fabric reinforced laminates were impregnated with freshly mixed EA9396 resin and then placed in 22°C (72°F) to 38°C (100°F) environments while observations were recorded on the state of the matrix resin. Table 28 presents the results of these tests.

It is apparent from the data in Tables 27 and 28 that the pot/work life is markedly shortened by increasing the temp e from 22°C (72°F) to 38°C (100°F). In addition, the effect of long-term storage is to reduce the available pot life and especially to shorten the time between first noticeable exotherm and final kick-over. In spite of the shortened pot-life or work-life available after extended storage for the conditions examined, the available time is still probably sufficient to permit most repairs to be satisfactorily completed.

3.7 EFFECT OF STORAGE TIME AND TEMPERATURE

The purpose of these tests was to determine how the processability of the material changed and whether good mechanical property levels could still be achieved after extended resin storage at ambient and elevated temperature. The tests listed in Table 3 were periodically conducted over a 30- month storage period. Samples of both parts A and B of a single batch of the EA9396 resin system were placed in storage at room temperature, 38°C (100°F) and 49°C (120°F). The samples were stored in the cans they were received in from the vendor.

The HPLC, FTIR, DSC and Rheometrics viscosity profile measurements failed to reveal any significant changes in the resin system as a result of 24 months storage at any of the three storage temperatures. Figure 4 presents HPLC spectra for part A of the EA9396 system in the freshly received condition (~3 months after manufacture) and after 18 months of storage at 49°C (120°F), respectively. Both spectra were generated using the same test parameters. It is evident that no significant difference appears. The HPLC spectra for 24 months at all three storage temperatures indicated equivalent behavior. Since no components are present in Part B of the EA9396 system that produce significant features in an HPLC spectra, this test was not performed on Part B.

TABLE 27

POT LIFE OBSERVATIONS FOR 200-GRAM BATCH OF EA9396 (1)

Storage Condition	Test Temperature	Time to First Notice of Exotherm (min. after mixing)	Time to Boil/Gel (2) (min. after mixing)
Freshly Received	22°C (72°F)	105	112/113
	39°C (100°F)	40	60/61
20 months at	22°C (72°F)	90	92/94
	38°C (100°F)	40	42/43

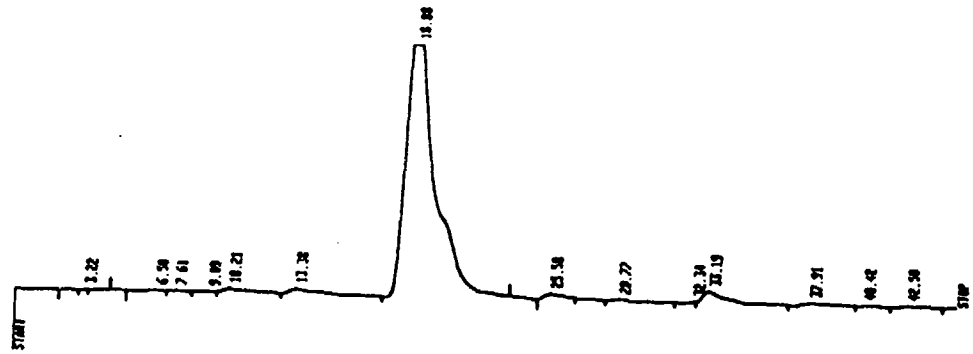
(1) Times listed were measured from completion of mixing.
(2) At the first times indicated, the two samples were so hot that they were bubbling and smoking. Gel followed within a minute of this.

TABLE 28

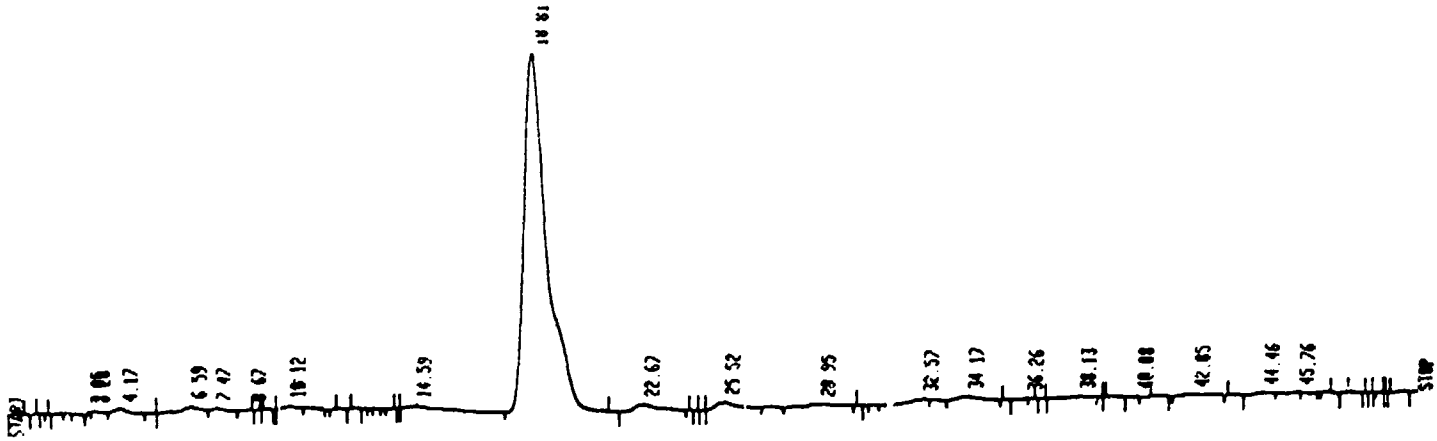
WORK LIFE OBSERVATIONS OF 12-PLY GRAPHITE LAMINATE IMPREGNATED WITH EA9396 A/B RESIN (1)

Temperature Environment	Maximum Midplane Temp. (2)	Time to Become Tacky (min) (3)	Time to Lose Tack (min) (4)	Time at Which Surface is no Longer Indentable (min) (5)
22°C (72°F)	29°C (84°F)	~60	210	240
38°C (100°F)	47°C (116°F)	~50	100	100

(1) Times listed were measured from completion of laminate impregnation. Impregnation required approximately 15 minutes after completion of mixing.
(2) Midplane temperature recorded with imbedded thermocouple.
(3) Subjective judgement of when resin changes from thick syrupy state to a sticky, nonliquid state.
(4) Subjective judgement.
(5) Unable to make an impression on surface of laminate with a wooden tongue depressor and hand pressure.



(a) Fresh Resin.



(b) Resin Aged for Eighteen Months at 49°C (120°F).

Test Parameters: Resin dissolved in dioxane
Flow rate: 1 ml/min
Gradient Profile

Time (minutes)	% Water	% Dioxane
0	50	50
10	50	50
40	30	70
50	30	70

Figure 4. HPLC Spectra of EA9396, Part A.

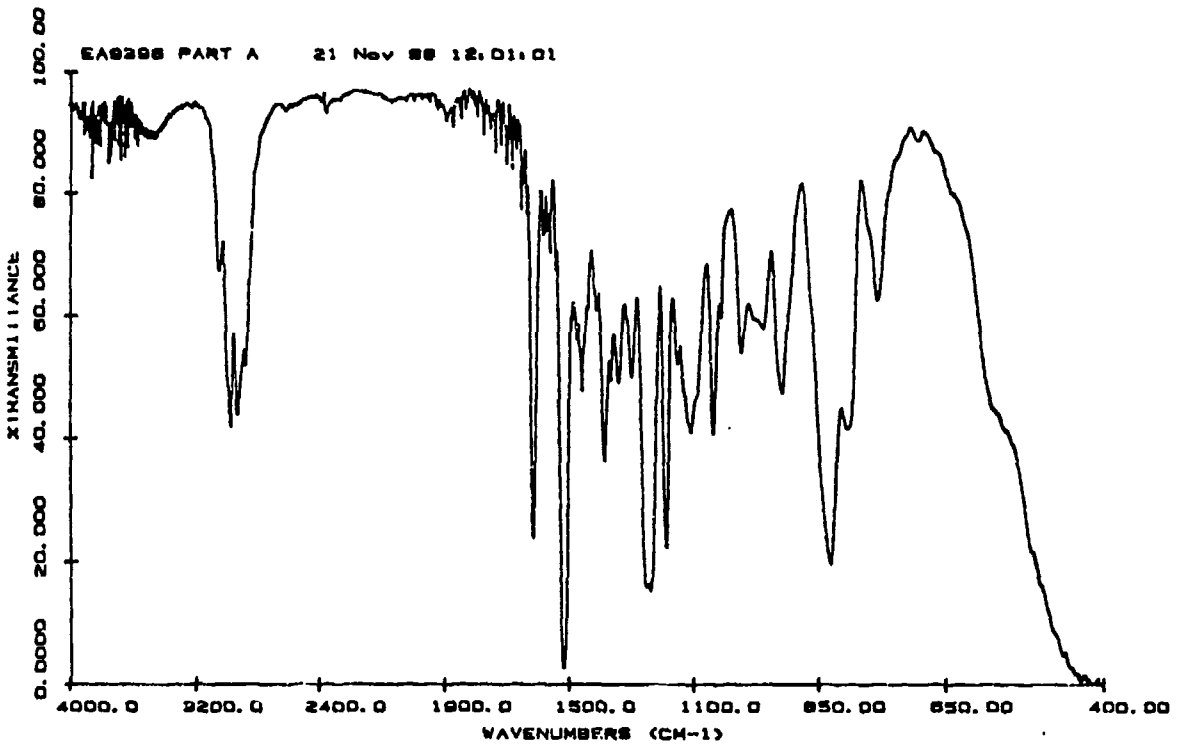
Figures 5 and 6 present FTIR spectra for both parts A and B in the fresh condition and after 24 months storage at 49°C (120°F). No significant changes between the fresh and 24-month aged material is apparent for either parts A or B.

Figure 7 presents a Rheometrics cure profile for fresh EA9396 material. Similar curves were obtained every 6 months for up to 24 months at each of the three storage temperatures. Table 29 lists key information extracted from each of these cure profiles. It is evident from the data in Table 29 that no changes are apparent as storage time increases.

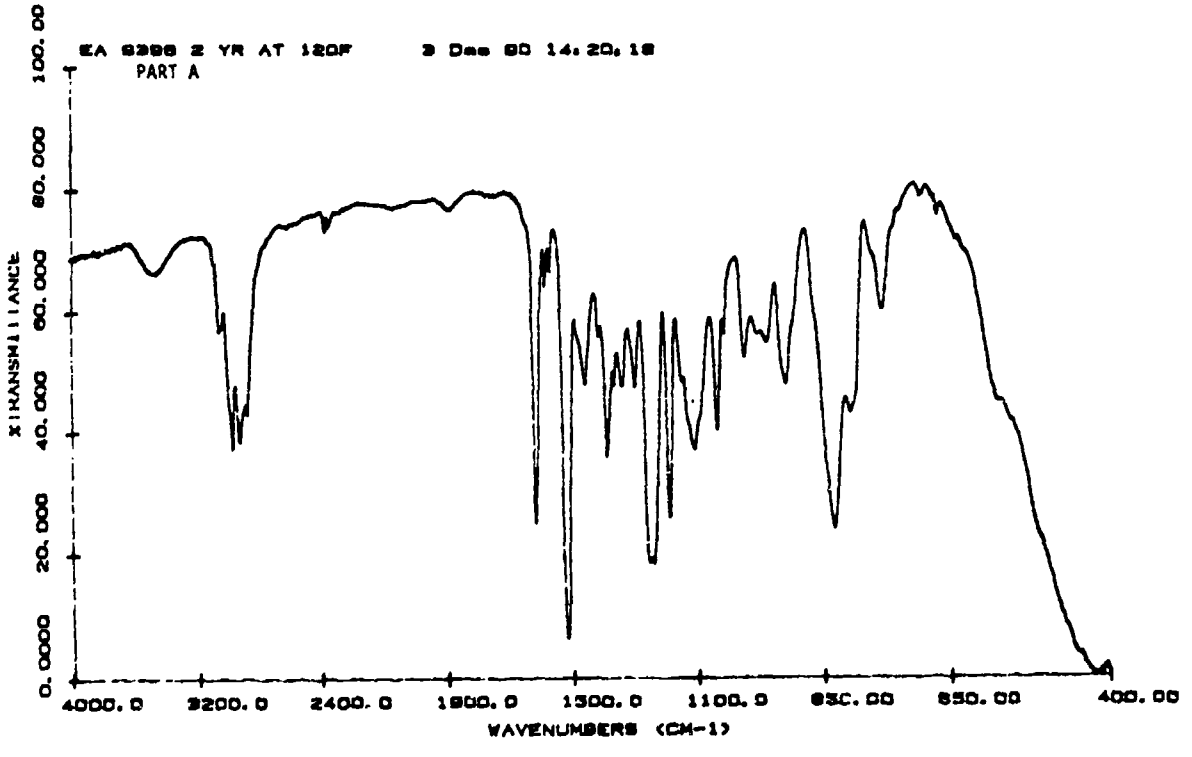
Figure 8 presents a DSC curve for fresh EA9396 material. Additional curves were generated every 6 months for up to 24 months at each of the three storage temperatures. Table 30 lists key information extracted from each of these DSC tests. As with the data from the cure profiles, no significant changes are apparent in the data of Table 30 as storage time increases.

The room temperature viscosity of parts A and B was also measured, using a Brookfield viscometer, as storage time increased. While the viscosity of the unmixed part B did not change during storage, part A did. Table 31 lists these changes. It is evident that at the 49°C (120°F) storage temperature viscosity starts to increase markedly after 12 months. After 30 months storage at 49°C (120°F), part A had become much too viscous to use at room temperature for wet layup impregnation of a laminate. After 36 months at 38°C (100°F), the viscosity of part A was still low enough to be processible by wet layup impregnation although the material was starting to show a marked viscosity increase. At the 22°C (72°F) storage condition, the resin was still usable after over four years.

In addition to the tests discussed above, the EA9396 resin samples that were in storage at the three different temperatures were also used to prepare graphite fabric reinforced laminates for interlaminar shear testing after various storage intervals. The interlaminar shear properties achievable from stored resin was not degraded at all so long as the viscosity remained low enough to permit wet layup impregnation of the reinforcement. In fact, it appears that an increased interlaminar shear strength is possible over time. Table 32 presents these data.

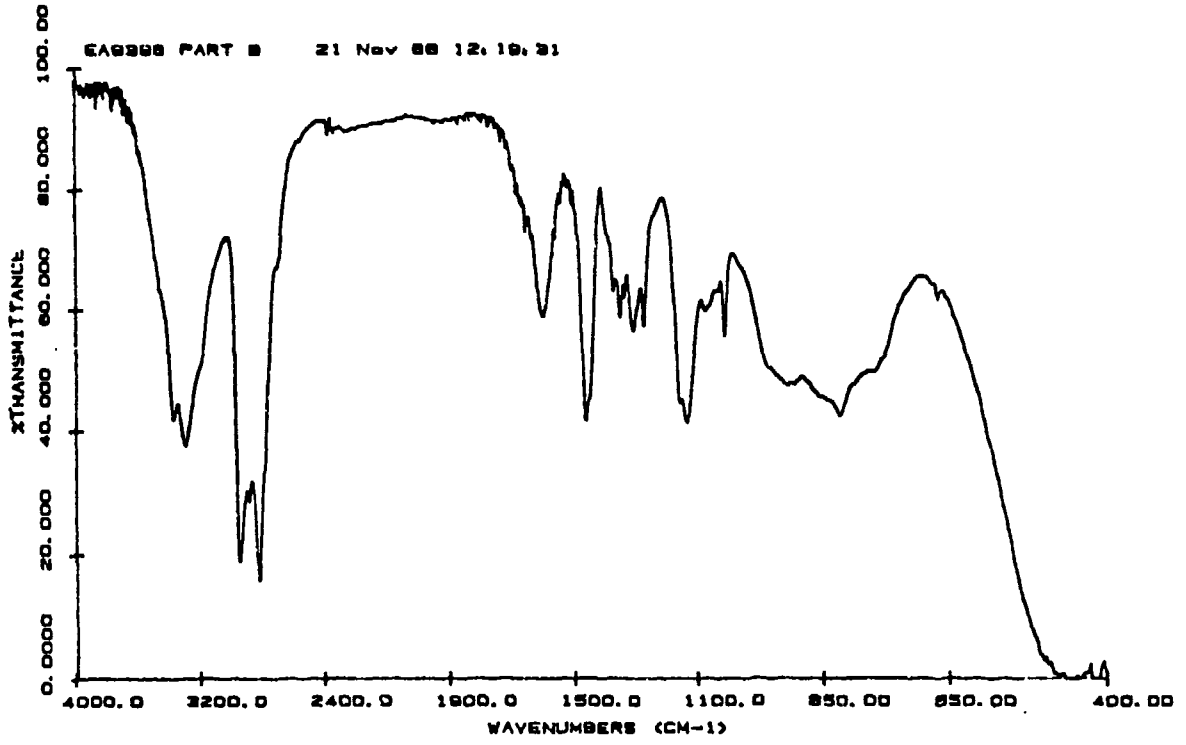


(a) Fresh Resin.

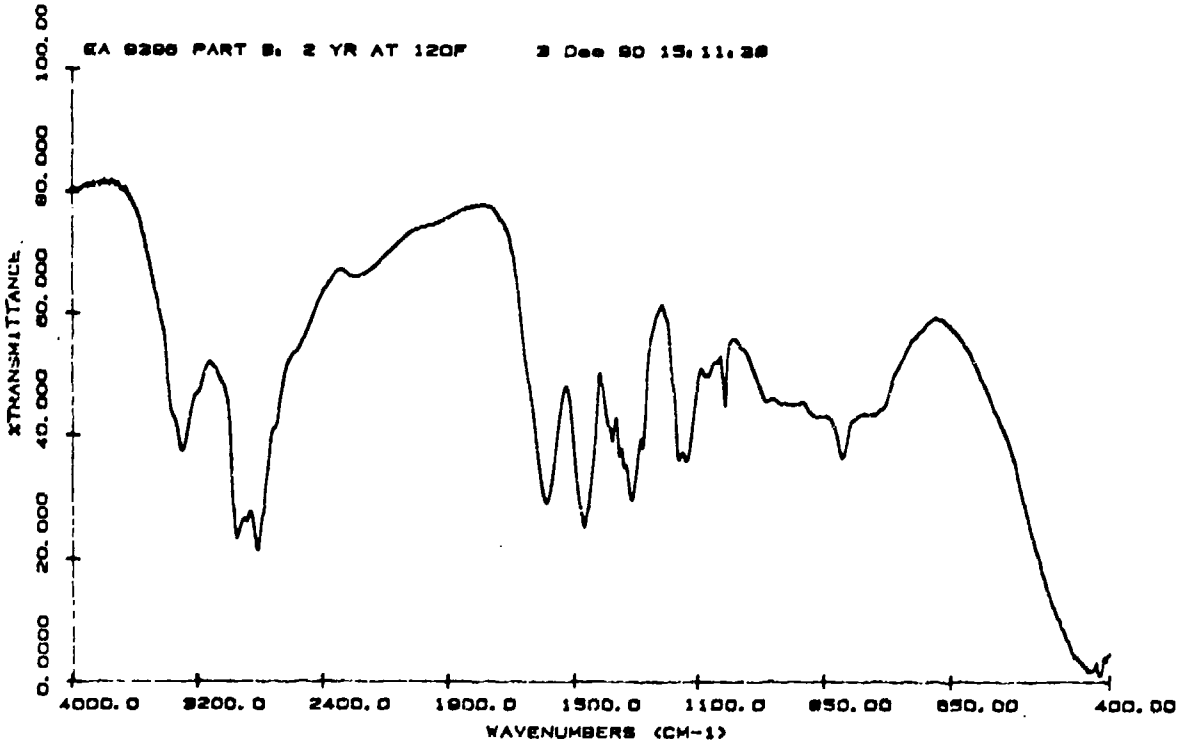


(b) Resin Aged for Two Years at 49°c (120°F).

Figure 5. FTIR Spectra of EA9396, Part A.



(a) Fresh Resin.



(b) Resin Aged For Two Years at 49°C (120°F).

Figure 6. FTIR Spectra of EA9396, Part B.

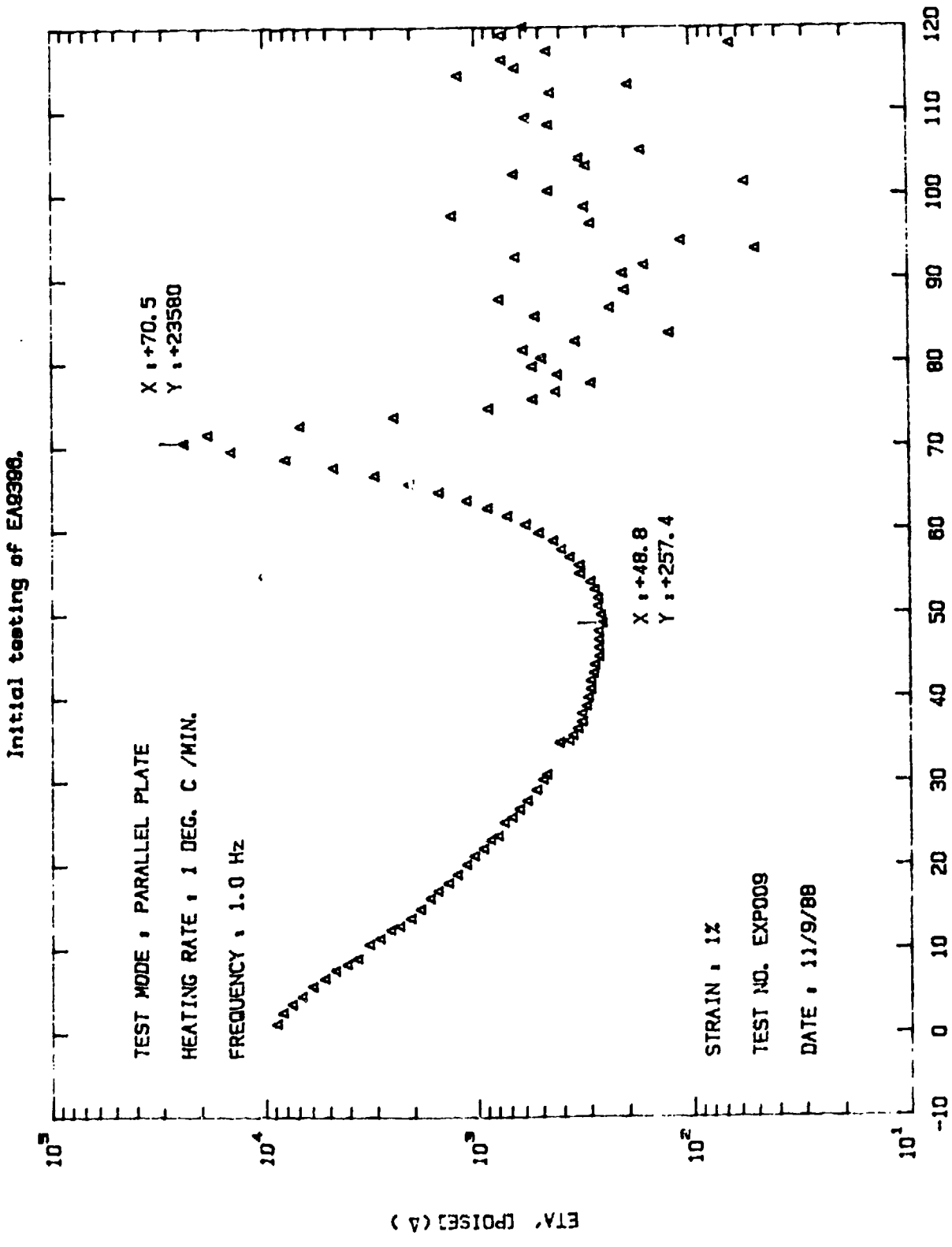


Figure 7. Rheometrics Viscosity Cure Profile for Fresh EA9396 Resin.

TABLE 29

EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON THE CURING VISCOSITY PROFILE CHARACTERISTICS OF EA9396

Storage Conditions	Temperature at Minimum Viscosity	Minimum Viscosity (poise)	Gel Temperature (°C)
Initial	49	~257	70.5
1 month at 38°C (100°F)	51	~150	71.6
1 month at 49°C (120°F)	47	~150	71.9
3 months at 22°C (72°F)	50	~40	73.3
6 months at 22°C (72°F)	48	~110	66.8
6 months at 38°C (100°F)	45	~110	65.9
6 months at 49°C (120°F)	44	~200	67.8
12 months at 22°C (72°F)	67	~149	71.9
12 months at 38°C (100°F)	66	~46	72.6
12 months at 49°C (120°F)	64	~64	71.4
18 months at 22°C (72°F)	49	~54	70.5
18 months at 38°C (100°F)	47	~54	68.4
18 months at 49°C (120°F)	47	~127	68.4
24 months at 22°C (72°F)	47	~60	71.6
24 months at 38°C (100°F)	50	~60	71.6
24 months at 49°C (120°F)	51	~120	70.5

NOTE: Test conducted on Rheometrics Solids Analyzer using a heating rate of 1°C (34°F)/minute.

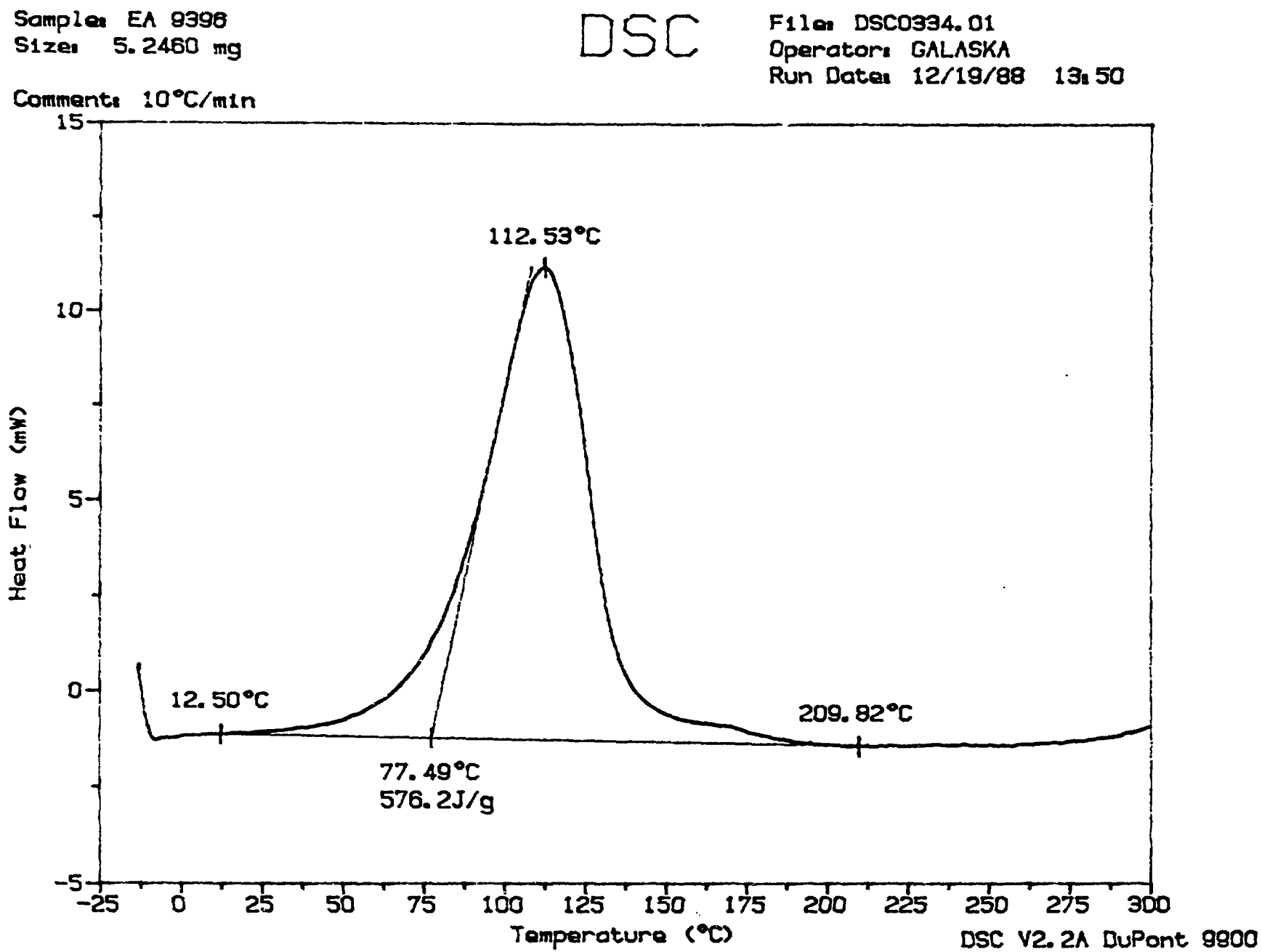


Figure 8. Heat Release Test Results for Fresh EA9396 Resin.

TABLE 30

EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON THE CALORIMETRIC CURE CHARACTERISTICS OF EA9396

Storage Conditions	Temperature at Reaction Peak (°C)	Total Heat of Cure (J/gm)
Initial	112.5	576.2
1 month at 38°C (100°F)	115.2	588.8
1 month at 49°C (120°F)	114.6	576.4
3 months at 22°C (72°F)	115.0	572.9
6 months at 22°C (72°F)	108.9	633.8
6 months at 38°C (100°F)	110.9	593.5
6 months at 49°C (120°F)	111.8	624.6
12 months at 22°C (72°F)	112.8	613.4
12 months at 38°C (100°F)	114.3	589.5
12 months at 49°C (120°F)	112.6	601.6
18 months at 22°C (72°F)	107.2	615.4
18 months at 38°C (100°F)	111.5	564.6
18 months at 49°C (120°F)	112.8	586.8
24 months at 22°C (72°F)	114.1	599.6
24 months at 38°C (100°F)	115.1	575.6
24 months at 49°C (120°F)	114.1	560.6

NOTE: Dynamic DSC test at heating rate of 10°C/minute under nitrogen.

TABLE 31

EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON THE VISCOSITY OF EA9396, PART A

Storage Temperature	Storage Time (1) (months)	Brookfield Viscosity of Part A	
		(Pa-s)	(Poise)
22°C (72°F)	Initial	84	840
	3	92	920
	6	72	720
	12	72	720
	18	112	1,120
	24	82	820
	30	78	780
	36	80	800
	43	100	1,000
	50	100	1,000
38°C (100°F)	1	84	840
	7	84	840
	12	96	960
	18	108	1,080
	24	84	840
	30	234	2,340
	36	460	4,600
	43	>2,000	>20,000(2)
	50	---	(3)
49°C (120°F)	1	88	880
	7	88	880
	12	100	1,000
	18	263	2,630
	21	344	3,440
	24	650	6,500
	30	>2,000	>20,000(2)

NOTES:

1. Months after receipt of resin. Resin was manufactured three months before receipt.
2. Material no longer processible into laminates.
3. Hard crust on surface.

TABLE 32

EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON ACHIEVABLE INTERLAMINAR SHEAR STRENGTH OF GRAPHITE-REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL

Storage Temp.	Storage Time (2) (months)	Interlaminar Shear Strength (3) DRY (MPa)	DRY (psi)	WET (4) (MPa)	WET (4) (psi)	Wt. Gain During Wet Aging(%) (4)
22°C (72°F)	Initial	37.56	5447	25.91	3758	3.91
	3	38.27	5515	31.46	4563	1.56 (5)
	6	42.60	6178	30.40	4409	2.68
	12	36.94	5357	29.95	4344	2.59
	18	42.21	6122	31.88	4624	2.65
	24	46.28	6712	32.00	4641	2.63
	43	45.59	6612	33.86	4910	2.86
	50	43.76	6347	---	---	---
38°C (100°F)	1	42.52	6166	32.82	4759	2.70
	6	42.77	6202	32.31	4686	2.61
	12	43.72	6341	32.77	4752	2.54
	18	44.32	6427	35.80	5192	2.65
	24	40.48	5871	28.05	4068	2.80
	43	45.59	6612	33.48	4856	3.02
49°C (120°F)	1	39.29	5698	29.83	4326	2.90
	6	42.88	6218	29.29	4247	2.79
	12	42.52	6167	26.08	3782	4.25
	18	46.41	6731	35.65	5170	2.65
	24	43.15	6257	31.59	4581	2.83

NOTES:

1. EA9396 Parts A and B stored at temperature listed for time listed before resin was mixed and laminate prepared.
2. From date of receipt. Resin was manufactured 3 months before receipt.
3. All tests were conducted at 22°C (72°F). Dry values represent average of three specimens, wet values represent average of two specimens.
4. WET = specimens immersed in water at 60°C (140°F) until saturated before being tested unless otherwise noted.
5. Immersed in water at 22°C (72°F) until saturated before being tested.

In summary, it appears that the EA9396 resin system is very tolerant of long-term storage. It is still useable after 24 months storage at 49°C (120°F) and after over 50 months storage at a temperature of 22°C (72°F).

3.8 EFFECT OF FIBER CONTENT

Since field or depot repairs may be subject to greater inconsistency in control of processing parameters than was the case in a laboratory environment, several laminates were prepared with deliberately lower fiber contents than the baseline laminates. These were then tested for both interlaminar shear and compressive properties. Both glass and graphite fabric reinforced laminates were prepared with fiber contents ranging from the standard 55% by volume down to as low as 34% by volume. The low fiber content laminates were all cured by the same "standard cure cycle", described in step (m) of Appendix A, that was used for the baseline laminates. The differences in fiber content were achieved by changing the bleeder ply/laminate ply ratio used during cure and/or the ratio of resin to reinforcement used during impregnation (see Table A.2 in Appendix A). Two attempts were made to obtain higher than normal fiber content laminates. In one case, the bleeder ratio was increased by 50% and the resin ratio reduced by 5% from the standard. In the other case, the bleeder ratio was not changed but the resin ratio was reduced by 27% from the standard. In each case, the resulting laminate exhibited practically identical physical characteristics (fiber content, void content) to the baseline laminates. This implies that one is not likely to obtain much higher fiber contents than that exhibited by the baseline laminates regardless of processing variations encountered in the field. The same should not be said with regard to void content since it is likely that some processing variations would affect porosity. Reduced fiber contents, on the other hand, were achieved by simultaneously reducing the bleeder ratio and raising the resin ratio during impregnation. In the extreme cases, in which the lowest fiber contents were achieved, the bleeder was eliminated entirely while the resin ratio used during impregnation was increased to 150% and 180% of the standard ratio for graphite and glass reinforced laminates, respectively. Interlaminar shear and compression specimens were machined and tested from these reduced fiber content laminates. The data from these tests are presented in Tables 33 and 34.

Examination of the data in Table 33 reveals several points. First, it appears that the interlaminar shear strength is influenced by both fiber and void content. In the case of the glass reinforced laminates, the two lowest shear strengths were produced by laminates that had significantly lower fiber content and significantly higher void content

TABLE 33

EFFECT OF RESIN/FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF EA9396 COMPOSITE LAMINATES

Panel Number	Reinforcement Fabric	Laminate Physical Properties				Interminar Shear Strength (1)			
						22°C(72°F), Dry		22°C(72°F), Wet(2)	
		Resin Content (% wt)	Fiber Content (% vol)	Void Content (% vol)	Specific Gravity	Number Replicates	Shear Strength MPa(psi)	Number Replicates	Shear Strength MPa(psi)
GL-31	E-7781, Glass	26.2	55.4	5.0	1.94	3	36.5(5290)	2	21.4(3110)
GL-30	"	26.7	54.3	6.1	1.89	3	38.2(5540)	2	21.9(3180)
GL-13R(3)	"	26.5	54.0	6.9	1.87	5	40.1(5810)	5	18.7(2710)
GL-33	"	28.4	52.3	6.4	1.86	3	37.8(5490)	2	20.5(2970)
GL-10	"	35.2	45.6	4.7	1.79	4	37.9(5500)	---	---
GL-54	"	43.6	35.8	8.8	1.62	3	33.2(4810)	---	---
GL-53	"	45.6	33.9	9.3	1.59	2	34.7(5030)	---	---
GR-51	T300-W133, Graphite	32.5	55.8	6.5	1.47	3	40.5(5870)	2	29.5(4280)
GR-52	"	33.6	54.7	6.4	1.47	3	40.4(5860)	2	32.7(4740)
GR-17(3)	"	35.6	54.6	4.0	1.48	5	39.1(5670)	5	32.7(4750)
GR-53	"	39.0	50.1	4.9	1.46	3	43.6(6320)	2	34.2(4960)
GR-54	"	39.0	49.8	4.7	1.47	3	43.8(6350)	2	35.3(5120)
GR-84	"	45.6	42.3	7.5	1.39	3	31.4(4550) (4)	---	---
GR-79	"	48.8	40.5	5.5	1.41	3	33.5(4860) (4)	---	---

NOTES:

(1) Four-point shear. Graphite tests at 16:1 span-thickness ratio, glass tests at 8:1 unless otherwise noted.

(2) Wet = wet aged at 60°C (140°F), 95-100% R.H. until saturation.

(3) Baseline panel data.

(4) Tests carried out at 12:1 span-thickness ratio.

TABLE 34

EFFECT OF RESIN/FIBER CONTENT ON 22°C (72°F), DRY COMPRESSIVE PROPERTIES OF EA9396 LAMINATES

Panel Number	Reinforcement Fabric	Laminate Physical Properties					Laminate Mechanical Properties(1)		
		Resin Content (% wt)	Fiber Content (% vol)	Void Content (% vol)	Specific Gravity	Number Replicates	Ultimate Compr. Strength MPa (10^3 psi)	Initial Modulus GPa (10^6psi)	Ult. Strain (10^{-6}in/in)
GL-53	E-7781, Glass	45.6	33.9	9.3	1.59	6	238(34.52)	17.0(2.5)	14,070
GL-54	"	43.6	35.8	8.8	1.62	6	254(36.85)	18.7(2.7)	15,560
GL-7,8(2)	"	28.1	53.7	4.4	1.90	5	287(41.69)	26.1(3.8)	11,670
GL-9(2)	"	27.6	53.8	5.0	1.84	5	269(39.08)	24.7(3.6)	11,730
GL-10R(2)	"	30.4	51.2	4.0	1.87	5	288(41.80)	24.8(3.6)	12,250
GR-79	T300-W133, Graphite	48.8	40.5	5.5	1.41	6	309(44.87)	37.3(5.4)	9,030
GR-84	"	45.6	42.3	7.5	1.39	---	298(43.18)	37.6(5.4)	8,020
GR-13,14(2)	"	35.9	54.6	3.6	1.48	5	414(60.08)	51.5(7.5)	7,920
GR-15(2)	"	34.7	55.5	4.3	1.48	5	410(59.50)	57.4(8.3)	8,150
GR-16(2)	"	34.9	54.9	4.8	1.47	5	435(63.03)	54.3(7.9)	8,700

NOTES:

(1) All tests conducted at 22°C (72°F), dry condition in fill direction of fabric reinforcement.

(2) Baseline panel data.

than the other five laminates. In the case of the graphite reinforced laminates, the two laminates with the lowest fiber content exhibited significantly lower shear strengths than the other five laminates. Similar behavior is observed in the case of the compressive properties, presented in Table 34. For both the glass and graphite reinforced laminates, the compressive strength is lowest for the laminates with low fiber content and high void content.

In summary, the shear and compression data in Tables 33 and 34 indicate that laminate strength is reduced with decreasing fiber content and increasing void content. For example, in Tables 33 and 34, panel numbers GL-53 and GL-54 had the lowest fiber contents and the highest void contents and also produced the lowest strengths. Similarly, panel GR-79 had the lowest fiber content and an intermediate void content and produced the second lowest strengths, while panel GR-84 had the second lowest fiber content and the highest void content and produced the lowest strengths. It also appears that the laminates that were deliberately prepared with low fiber contents generally had higher void contents than baseline laminates. This indicates that low fiber content (resin-rich) laminates should be avoided if optimum properties are desired.

3.9 ALTERNATE IMPREGNATION AND BAGGING SCHEMES

Appendix A describes the rationale behind the individual steps in the "standard processing procedure." This procedure was selected for use in the laboratory because it was convenient and because it produced laminate quality consistent with what would be expected in repair scenarios using a vacuum bag curve. A number of laminates were prepared during the program, however, by procedures that differed from the standard procedures. These differences were in the areas of ply impregnation procedures, bleeder material used, and bagging scheme employed. Each of the activities undertaken in these respective subject areas are discussed in the following sections.

3.9.1 Alternate Ply Impregnation Procedure

It was recognized that repair technicians working in the field might elect to employ different processing procedures than were used here. In order to anticipate what these different procedures might be, and to determine their effects on resulting laminate quality, two variations from the standard ply impregnation procedure were investigated.

In the first, the resin was applied to every ply instead of every other ply as in the standard procedure. In the second, a lower ratio of resin to reinforcement was employed during the impregnation steps than in the standard procedure. Each of these variant procedures is described in detail in Appendix B but a brief summary of each is presented in the following paragraphs.

The first variant impregnation procedure involved applying resin to every reinforcement ply during the wet layup procedure instead of every other ply. The reason for doing this was to determine whether laminate quality (specifically, void content) would be adversely affected. Since only half as much resin was available to be applied and worked into each ply, it was thought that resin distribution might be less uniform and that more voids due to air entrapment might result. As in the "standard procedure," the total amount of resin used during impregnation represented a 50% excess over what was desired in the final laminate. The same amount was applied to every ply, including the first and last, as opposed to the resin distribution approach described in steps (e)-(j) of Appendix A. Other than this, all other steps were identical to those described in Appendix A.

The physical properties of specimens cut from this panel are presented in Table 35. Table 35 shows that while this laminate had a slightly higher void content than the baseline laminates made with the standard processing procedure (Table 4), the difference was within the range of the standard deviation of the baseline panels. The other physical properties are also very nearly equivalent to those exhibited by the baseline panels.

The second variant impregnation procedure involved using a smaller quantity of resin during impregnation of the reinforcement plies than the amount computed in step (c) of Appendix A. The reason for doing this was to determine whether equivalent laminate quality (specifically void content) could be achieved without bleeding excess resin out of the wet layup stack. Instead of the 50% excess used in the standard procedure, the amount used for this laminate represented 0% excess (nominally net resin content). Thus, the resin/reinforcement ratio employed for this laminate was only 0.370 gm resin/gm reinforcement instead of the 0.555 gms listed in Table A.2. The other difference was that since no excess resin was used, no bleeder plies were used during cure. Other than these two variations, all other steps were identical to those described in Appendix A.

TABLE 35

PHYSICAL PROPERTIES SUMMARY OF LAMINATES
PREPARED WITH VARIANT PROCESSING PROCEDURES

Type of Laminate	Processing Variation	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
E-7781 (Gl)/EA 9396	Every ply impregnated	1.87	0.21	8.1	52.6	28.4	5.9
E-7781 (Gl)/EA 9396	Net resin used during impregnation and no bleeding	1.85	0.20	7.9	50.3	30.8	4.8

The physical properties of specimens cut from this panel are presented in Table 35. It is evident from these data that void content was not adversely affected by this alternative processing procedure. It does appear, however, that the panel was somewhat more resin-rich than the baseline panels made with bleeder plies during cure. This is probably because the amount of resin used was only nominally net resin content, not precisely net resin content.

Based on these two variations in resin impregnation procedures, it appears that essentially equivalent laminate quality can be achieved with a variety of procedures.

3.9.2 Alternative Bleeder Materials

All of the baseline laminates prepared during this program, as well as nearly all the other laminates prepared in accordance with the "Standard Laminate Processing Procedure," were bagged according to Figure A.1 using Mochburg CW 1850 bleeder, which had an area weight of 71 gm/m^2. It was empirically determined that this bleeder material typically absorbed about three times its own weight of EA9396 resin during a cure cycle when used in the ply ratios listed in Table A.2. This was used as bleeder material only because it was readily available and because of prior experience with it. It was recognized, however, that in field repair scenarios, this particular bleeder material might not be available. Several laminates were, therefore, prepared using the same fabric material as bleeder as was used for reinforcement in the wet layup, specifically, the E-7781 glass and T300-W133 graphite fabrics described in Table 1. The absorptivity of these materials as bleeder was characterized, and the physical properties of the laminates made using them were determined to demonstrate equivalence to the baseline laminates made using the standard processing procedure. The procedure used to determine bleeder material absorptivity is described in Appendix R. Table 36 summarizes the results obtained for the laminates made with the glass and graphite fabric as bleeder material. Other than the bleeder material, these laminates were prepared in accordance with the standard procedure described in Appendix A.

3.9.3 Alternative Bagging Schemes

The standard laminate bagging scheme, illustrated in Figure A.1, was employed for the large majority of the laminates prepared in this program. Two alternative bagging schemes were investigated, however, in an effort to see if the void

TABLE 36

PHYSICAL PROPERTIES SUMMARY FOR LAMINATES
PREPARED WITH ALTERNATIVE BLEEDER MATERIAL

					Laminate Physical Properties (2)				
Type of Laminate	Bleeder Material	Bleeder Area Density (gm/m^2)	Bleeder/ Laminate Ply Ratio	Bleeder Absorptivity(1) gm/gm (gm/m^2)	Specific Gravity	Ply Thickness mm (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
E7781(G1)/ EA9396	E-7781 Glass	295	3/16	0.41 (122)	1.84	0.20 (7.8)	50.0	30.7	5.6
E7781(G1)/ EA9396	E-7781 Glass	295	2/8	0.50 (148)	1.85	0.21 (8.2)	49.5	31.6	4.5
E7781(G1)/ EA9396	E-7781 Glass	295	3/8	0.41 (122)	1.89	0.23 (8.9)	52.5	29.2	4.2
E7781(Gl)/ EA9396	CW1850	71	2/8	3.0 (213)	1.91	0.20 (8.0)	55.2	26.6	5.1
T300-W133 (Gr)/EA9396	T300-W133 Graphite	366	3/12	0.54 (198)	1.48	0.37 (14.4)	55.4	33.1	5.8
T300-W133 (Gr)/EA9396	T300-W133 Graphite	366	3/8	0.47 (172)	1.49	0.39 (15.4)	53.5	36.0	4.5
T300-W133 (Gr)/EA9396	CW1850	71	5/12	3.0 (213)	1.48	0.36 (14.3)	55.8	33.6	4.9

(1) Grams resin absorbed per gram or per square meter of bleeder material.
(2) All laminates cured 45 minutes at 93°C (200°F) under vacuum bag pressure.

content could be reduced by means readily available to technicians carrying out field repairs.

The first variant was to perforate the normally nonporous barrier between the bleeder material and the breather material. The rationale for this was that this perforation permits the vacuum, when it is applied, to draw air out of the bleeder instead of forcing it into the layup. It was speculated that air might be trapped in the bleeder when the vacuum was applied because the caul plate would be pressed down so tightly that air escape paths would be shut off. The altered layup scheme is described in detail and illustrated in Appendix B. Instead of separating the bleeder material from the breather material with the two layers of nonporous teflon and a caul plate, the modified layup scheme consisted of a single layer of nonporous teflon film with a series of knife slits separating the two. A glass fabric reinforced laminate was prepared in this manner. Physical and interlaminar shear properties of this laminate were determined. Table 37 presents the data for this laminate and also for comparable baseline laminates. While the physical properties of the experimental laminate prepared with the perforated film procedure are slightly inferior to those exhibited by the laminates made with the baseline procedure, the interlaminar shear strength is about 15 percent higher. Since the higher void content of the experimental laminate is higher than that of the baseline laminates, one would normally expect the interlaminar shear properties to be lower. The only reason that can be offered to explain this is that the experimental laminate was made approximately 12 months after the baseline laminates. As was discussed in Section 3.7, interlaminar shear properties delivered by laminates made with 1 year old resin are higher than those delivered by laminates made with relatively fresh resin (by about 11% in the case of 22°C (72°F) dry tests -- see Table 32).

The second variant was to ulitize a double-bag vacuum scheme rather than the single-bag scheme illustrated in Figure A.1. The rationale for this approach was that while the vacuum applied in the single bag scheme supposedly aids in drawing air and volatiles out of the laminate, the compaction of the layup resulting from the vacuum bag may pinch off escape paths and trap air and volatiles in the layup. The idea of the double bag scheme is to permit the layup to "breathe" even while under vacuum by reducing the compacting force during the early part of the cure cycle. The double bag layup scheme is described in detail and illustrated in Appendix B. A graphite fabric reinforced laminate was prepared using this double bag scheme and both physical and interlaminar shear properties of this laminate were determined. Table 38 presents these data for both this

TABLE 37

EFFECT OF PERFORATED FILM PROCESSING MODIFICATION ON LAMINATE PROPERTIES

Laminate Type	Processing Procedure	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Specific Gravity	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)	Interlaminar Shear Strength (1) (MPa)	Interlaminar Shear Strength (1) (Psi)
E-7781 (Gl)/EA9396	Standard (App. A)	0.20	8.0	1.91	55.2	26.6	5.1	39.3	5700
E-7781 (Gl)/EA9396	Perforated Film (App. B)	0.19	7.6	1.86	52.8	27.6	6.7	45.2	6560

(1) All tests performed on dry, as-fabricated laminates at 22°C (72°F).

TABLE 38

EFFECT OF DOUBLE-BAG PROCESSING MODIFICATION ON LAMINATE PROPERTIES

Laminate Type	Processing Procedure	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Specific Gravity	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)	Interlaminar Shear Strength (1) (MPa)	Interlaminar Shear Strength (1) (Psi)
T300-W133 (Gr)/EA9396	Baseline (App. A)	0.36	14.3	1.48	55.8	33.6	4.9	39.3	5700
T300-W133 (Gr)/EA9396	Double Bag (App. B)	0.39	15.2	1.48	55.0	33.6	5.9	43.4	6300

(1) All tests performed on dry, as-fabricated laminates at 22°C (72°F).

laminate and also for comparable baseline laminates. While the physical properties of the experimental laminate prepared with the double-bag vacuum scheme are essentially equivalent to those exhibited by laminates made with the baseline procedure, the interlaminar shear strength values are about 10 percent higher. As noted for the laminate made with the perforated film (Table 37), the higher interlaminar shear strength listed in Table 38 for the double-bag laminate may well be attributable to the fact that the EA9396 resin used for this laminate was 13 months older than that used for the baseline laminates. Again, Table 32 shows that 1 year old resin produces an interlaminar shear strength about 11% higher than fresh resin.

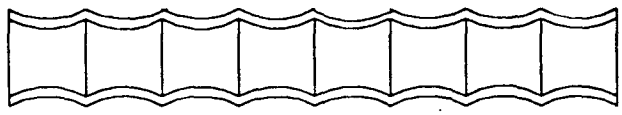
Based on the results of these two modified bagging schemes, it appears that both produced laminates that were essentially equivalent to those produced by the standard baseline processing procedure.

3.10 HONEYCOMB SANDWICH BEHAVIOR

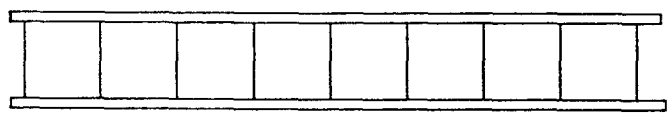
Two types of honeycomb sandwich specimens were made and tested, edgewise compression, and flatwise tension. The former type specimens were utilized to investigate whether skin dimpling, if it occurred, would reduce the edgewise compression strength. The latter type specimens were utilized to investigate the effects of adhesive fillet size on flatwise tensile strength. Both specimen types consisted of honeycomb core with composite skins bonded to the core with a layer of epoxy adhesive (EA9394 by Dexter Hysol). The honeycomb core was either 126.5 Kg/m^3 (7.9 lb/ft^3) or 91.3 Kg/m^3 (5.7 lb/ft^3) density material. Both cores were from Hexcel and were designated CRIII-1/4-5052-.004N-7.9 and CRIII-3/16-5052-.002-5.7, respectively. These two honeycomb sandwich investigations are discussed in detail in the following sections.

3.10.1 Effect of Skin Cocuring on Edgewise Compression Behavior

When skin repairs are made on honeycomb core substrates, the skin is relatively thin, typically as few as only two plies in some cases. If the skin is cocured, under a compacting vacuum bag pressure, the cured skin may exhibit the imprint of the honeycomb substrate. This is called dimpling and results in a skin that is not flat, but is somewhat rippled, as illustrated in Figure 9. Since one failure mode in edgewise compression can consist of skin buckling, it was felt that if dimpling does occur during cocure, the resulting edgewise compression strength may be reduced from what it would be with straight, undimplied skins.



(a) Dimpled skin (exaggerated) resulting from cocuring composite skin and adhesive under vacuum bag compaction.



(b) Flat, undimpled skin resulting from precuring the composite skin on a flat tool and then bonding it to the core in a second step.

Figure 9. Comparison of Cocured and Secondarily Bonded Honeycomb Sandwich Skins.

This possibility was investigated by preparing honeycomb sandwich panels both by cocuring and by secondarily bonding flat composite skins to the core. When graphite fabric was used for the skin, each skin was two plies thick. When glass fabric was used, each skin was four plies thick, since the glass fabric plies were only about half as thick as the graphite plies. On all sandwich panels, an adhesive layer consisting of a ply of style 120 glass fabric impregnated with 0.21 gm/cm^2 EA9394 paste adhesive was used to bond the skin to the core. This paste adhesive layer was used because the viscosity of the EA9396 resin used in the skins became so low during cure that satisfactory filleting along the honeycomb cell walls could not be achieved. Two different cores were used: one with a 6.35-mm (1/4-inch) cell size and one with a 4.76-mm (3/16-inch) cell size. It was felt that if skin dimpling indeed did occur and caused a reduction in edgewise compression strength, the effect would be greater for a larger cell size and lesser for a smaller cell size.

In the case of the cocured panels, the skins were impregnated in the standard manner, as described in Appendix A. The bottom skin rested on a flat tool surface while the upper skin was atop the core (and adhesive layer). The entire sandwich assembly was bagged in accordance with the layup illustrated in Figure A.1 except that no caul plate was used. The cure cycle was the same as that described in Appendix A.

In the case of the secondarily bonded panels, the two skins were prepared by the standard processing procedure described in Appendix A. These were then bonded to the core using a layer of EA9394 adhesive on a style 120 glass carrier fabric between each skin and the core. The two skins were lightly sanded and wiped with solvent prior to bonding to ensure a clean surface. The adhesive was cured for 1 hour at 93°C (200°F) under vacuum bag pressure.

The cocured panels were 30.5 x 30.5 cm (12 x 12 inches) and three specimens 7.6 x 22.9 cm (3 x 9 inches) were machined from each panel. The secondarily bonded specimens were prepared individually in a 10.2 x 25.4-cm (4 x 10-inch) dimension, then trimmed to the final specimen size. Individual specimens were secondarily bonded because it was found that secondary bonding of large panels resulted in disbonds. These were manifested as large blisters in the center of the panels. All specimens, whether cocured or secondarily bonded, were oriented such that the fill fibers in the fabric reinforced skins were in the length direction of the specimens.

Table 39 summarizes the results of the edgewise compression tests. As the data in Table 39 indicate, the cocured samples produced higher compression strengths than the secondarily bonded samples, by around 15-20%. All of the secondarily bonded samples failed by virtue of the skin debonding from the adhesive layer. All of the cocured samples exhibited compressive failure of one or both skins and no debonding of either skin from the adhesive layer. In addition to the failure modes described above, most of the samples made with the lower density core, regardless of the type skin/core bond, exhibited general buckling. No evidence of skin dimpling was observed on any of the cocured panels.

3.10.2 Effect of Fillet Size on Flatwise Tensile Strength

Several preliminary attempts were made to prepare honeycomb sandwich panels in which the EA9396 resin in the composite skins served simultaneously as the skin-to-core adhesive. This proved generally unsuccessful because the viscosity of the EA9396 resin became so low during cure that satisfactory filleting along the honeycomb cell walls could not be achieved along the upper skin. Suitable fillets did form on the lower skin because the resin from the upper skin ran down the cell walls and accumulated along the lower skin-to-core interface. As a consequence, it was found that suitable fillets, and a reasonable strength of the skin-to-core bond could only be achieved by the addition of a layer of paste adhesive between the skins and core. As noted earlier in Section 3.10.1, this paste adhesive layer consisted of a ply of style 120 glass scrim fabric impregnated with EA9394 epoxy adhesive. This adhesive is a filled version of the EA9396 resin system.

Since flatwise tensile strength of a sandwich construction is influenced by the size of the fillets that are formed, the purpose of the investigation described in this section was to determine how much the flatwise tensile strength is affected by various fillet sizes. Fillet size was varied by applying different amounts of adhesive to the style 120 glass scrim cloth.

Table 40 summarizes the results obtained in this study. It includes data for honeycomb panels made with no adhesive layer, with an adhesive layer along the top skin only, and with an adhesive layer of various weights along both skins. It is evident from the data in this table that the flatwise tensile strength increases as the amount of adhesive, and the accompanying fillet size, are increased. There is a dramatic increase in flatwise tensile strength as the amount of adhesive increases from zero to about

TABLE 39

EFFECT OF SKIN BONDING APPROACH ON EDGEWISE COMPRESSION STRENGTH

Skin Type (1)	Core Density $(gm/m^3)(lb/ft^3)$	Type Bond (2)	Facing Stress at Failure (3) Average MPa (10^3 psi)	Facing Stress at Failure (3) Std. Deviation MPa (10^3 psi)	Failure Mode
T300-W133 Graphite, 2-ply	115 (5.7)	Cocured	286 (41.5)	47.8 (6.9)	buckling, skin compression
		Secondary	244 (35.3)	38.5 (5.6)	skin debonding
	160 (7.9)	Cocured	326 (47.2)	15.7 (2.3)	skin compression
		Secondary	271 (39.3)(4)	---	skin debonding
E-7781 Glass, 4-ply	115 (5.7)	Cocured	294 (42.6)	10.6 (1.5)	buckling, skin compression
		Secondary	252 (36.6)	62.7 (9.1)	buckling, skin debonding

(1) In both the cocure and secondary bonding processes a layer of EA9394 adhesive on a fiberglass scrim was used between the skins and the core to assure satisfactory filleting on both skins.

(2) Cocured = Skins cured and bonded to core simultaneously.
Secondary = Skins cured separately then bonded to core in a second operation.

(3) Values represent average of three specimens unless otherwise indicated. All tests at 22°C (72°F).

(4) Two specimens.

TABLE 40

EFFECT OF ADHESIVE APPLICATION RATE ON FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH

Sandwich Description			Fillet Size (2)			Failure Mode (4)			
Core	Skin	Adhesive Application Rate (1)	Top Skin (mm)	Bottom Skin (mm)	Flatwise Tensile Strength (3) (MPa) (psi)	A (%)	A/C (%)	A/S (%)	S (%)
CRIII-1/4-5052-.004N-7.9 2.54cm (1 in) thick	2-ply T300-W133 Gr/EA9396 Comp. each face	None	0.1-0.3	0.3-0.5	1.7 (248)	30	10	60	0
						----------(NOTE 5)----------			
"	"	0.21 gm/cm^2 adh. between core and top skin only	~1.5	0.3-0.5	4.2 (607)	92	8	0	0
						----------(NOTE 6)----------			
"	"	0.08 gm/cm^2 adh. between core and both skins	~0.5	~0.5	5.2 (751)	35	60	5	0
"	"	0.21 gm/cm^2 adh. between core and both skins	~1.5	~1.5	5.8 (846)	10	50	40	0
"	"	0.73 gm/cm^2 adh. between core and both skins	3.2-4.7	3.2-4.7	6.7 (980)	3	30	34	33

NOTES:

1. EA9394 adhesive on Style 120 glass resin cloth.
2. Estimated from microscopic examination of specimens after testing.
3. Average of three or four specimens. All tests performed at 22°C (72°F).
4. A = cohesive failure within the adhesive (between the base of the fillet and the adhesive layer)
   A/C = failure at fillet-to-core interface (bare cell wall)
   A/S = failure at adhesive to skin interface
   S = delamination of skin
5. Failure located between core and top skin.
6. Failure located between core and bottom skin.

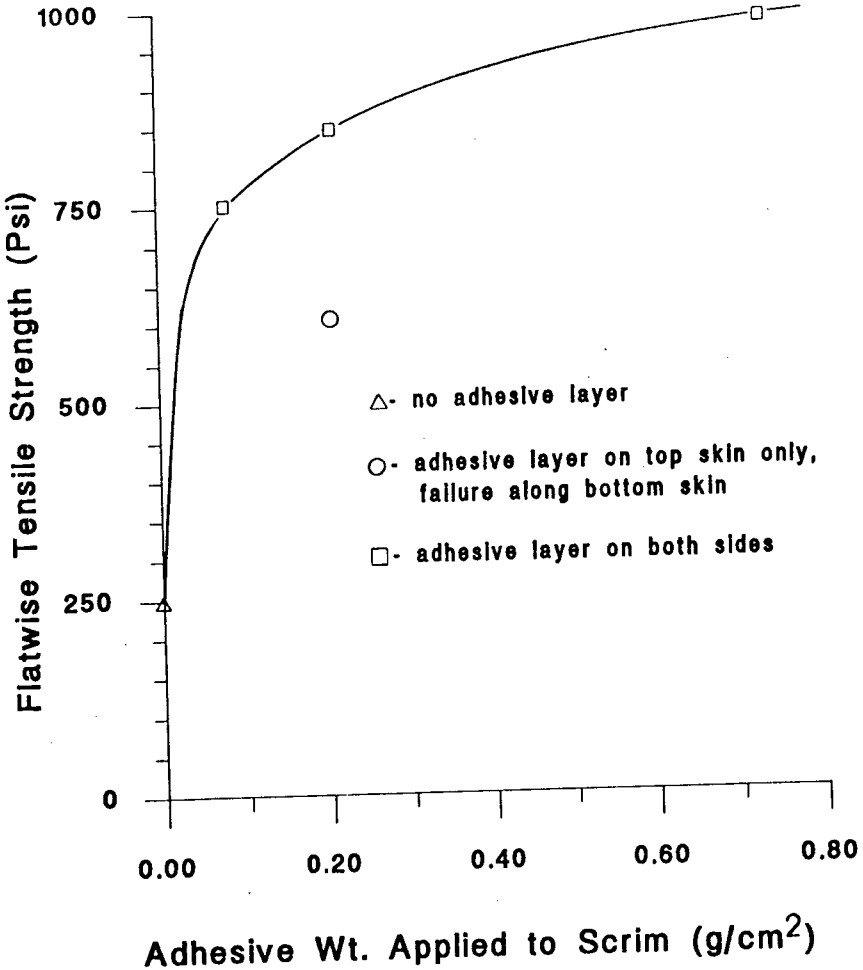
0.08 gm/cm^2 along the skin-core interface. Above this weight of adhesive application, additional strength increases are achieved but at a much lower rate. Figure 10 illustrates the relationship between adhesive application rate and resulting flatwise tensile strength and the relationship between fillet size (or area of contact between adhesive and core cell walls) and adhesive application rate. With no adhesive at all, the fillets result solely from the EA9396 matrix resin in the sandwich skins, and the fillet size ranges from nearly zero along the upper skin (0.1-0.3 mm by visual estimate) to approximately 0.3-0.5 mm along the lower skin. In those cases where a layer of EA9394 adhesive was employed, the fillet sizes ranged from approximately 0.5 mm for an adhesive application rate of 0.08 gm/cm^2, to 1.5 mm for a rate of 0.21 gm/cm^2, and 4 mm for a rate of 0.73 gm/cm^2.

While it is evident that flatwise tensile strength levels can be raised significantly by the use of large quantities of adhesive, and that without an adhesive layer the strength levels are quite low, a point of diminishing returns is reached at adhesive application rates in the vicinity of 0.1 gm/cm^2. Above this level the increases in strength that can be achieved may not be worth the weight penalty that accompanies it.

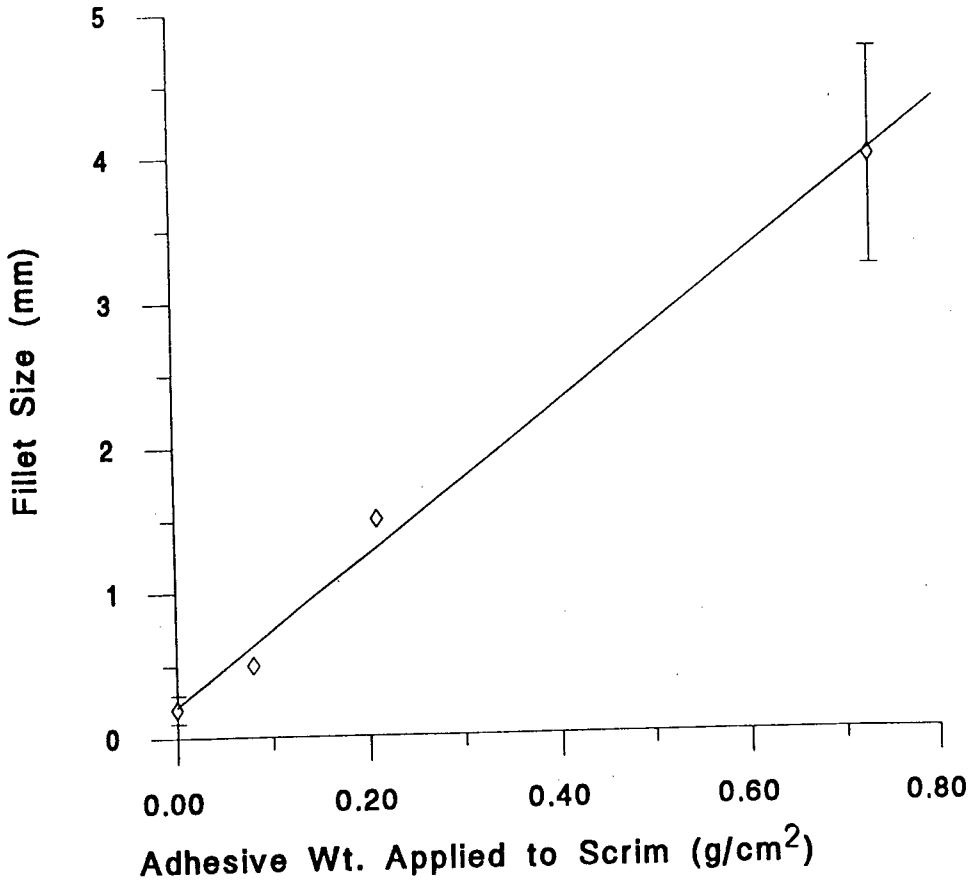
3.11 EFFECT OF SIZING ON GLASS FABRIC LAMINATES

Except for the work reported in this section, all of the glass-reinforced laminates made and tested during this program had a Volan-A type fiber sizing. This fiber sizing was used because it is the most commonly used fiberglass sizing and is epoxy-compatible, even though it is not the most environmentally durable finish. It was felt that there was a high likelihood of Volan-sized glass fabric being used in repairs, and the data would therefore provide conservative numbers. The property levels delivered by glass-reinforced laminates made with Volan-A sized fiber were listed in the various tables in Section 3.2. It is evident from these data that very significant property losses are encountered as a result of moisture absorption. Because of this substantial moisture-induced property degradation, it was decided to prepare and test a limited quantity of glass-reinforced laminates that incorporated a silane sizing rather than the Volan-A type sizing.

Laminates using silane-sized glass fabric were prepared in the same manner as those for which property data are reported in Sections 3.2.1, 3.2.3, and 3.2.4. The standard processing procedure described in Appendix A was followed in the preparation of these silane-sized laminates. Tensile, inplane shear and interlaminar shear properties were generated from specimens machined from these laminates, and the results of these



(a) Effect of Adhesive Application Rate on Flatwise Tensile Strength



(b) Effect of Adhesive Application Rate on Fillet Size

Figure 10. Effect of Adhesive on Fillet Size and Flatwise Tensile Strength of Sandwich Constructions.

tests are presented in Tables 41-43. It is apparent from these tables that the silane-sized fiber produces appreciably higher strength retention after wet aging than the Volan sizing.

3.12 EFFECT OF NONBASELINE ENVIRONMENTAL EXPOSURE

The baseline environmental exposure condition utilized during this investigation was a wet-aging exposure at conditions of 60°C (140°F)/100% R.H. until saturation was achieved. This was followed by mechanical testing at -54°C (-65°F), 22°C (72°F), or 93°C (200°F). Two nonbaseline types of environmental exposure were carried out, however, to assess durability of the repair material to various thermal environments. These are described in the following two sections.

3.12.1 Elevated Temperature Exposure

The purpose of this test was to determine whether exposure to 177°C (350°F) was detrimental to composite mechanical properties, specifically interlaminar shear. This was of interest because a repair initially cured at 93°C (200°F) might, at some later date, be exposed to one or more 177°C (350°F) cure cycles. Two exposure levels, 2 hours and 16 hours at 177°C (350°F), were carried out. Interlaminar shear tests were conducted after these exposures and the results are presented in Table 44. No degradation is evident in the shear strength values for the glass reinforced material in spite of the visual darkening that was evident. In the case of the graphite reinforced material, the shear strengths after the 177°C (350°F) exposures are approximately 15% lower than the baseline shear strength levels.

3.12.2 Exposure to Thermal Pulse

Both graphite and glass reinforced laminates were painted on one side with a standard aircraft paint scheme in a dark gray shade. Some of these painted laminates were humidity aged until saturated while some were stored in a desiccated environment. After completion of the environmental exposure, these laminates were exposed, on the painted side, to a thermal pulse by means of a quartz lamp bank. A Mach 0.7 air flow was maintained over the laminates during the thermal pulse and the laminates were not loaded.

After exposure to the pulse, the laminates were machined into compression specimens and tested for residual strength. Tables 45 and 46 present the

TABLE 41

LONGITUDINAL (WARP) TENSILE PROPERTIES OF A1100-SIZED GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Test Condition	Fiber Sizing	Test Direction	Ultimate Strength (MPa)	(psi)	Tensile Modulus (GPa)	(10^6 psi)	Ult. Strain (10^{-6} in/in)
22°C(72°F), Dry	A1100	Warp	280.8	40,760	24.5	3.55	11,880
22°C (72°F), Wet(2)	A1100	Warp	246.5	35,780	21.6	3.14	12,130
93°C (200°F), Wet(2)	A1100	Warp	170.6	24,760	18.8	2.73	9,520
22°C (72°F), Dry	Volan (3)	Warp	356.6	51,750	24.9	3.62	17,740
22°C (72°F), Wet	Volan (3)	Warp	112.9	16,390	22.7	3.30	5,100
22°C (72°F), Wet	Volan (3)	Fill	120.9	17,540	23.9	3.47	5,410
93°C (200°F), Wet	Volan (3)	Fill	93.3	13,540	20.7	3.01	4,470

(1) All average values represent five specimens.
(2) WET = wet aged at 60°C (140°F)/100% R.H. until saturation.
(3) The Volan sized fiber panels represent the baseline data.

TABLE 42

IN-PLANE SHEAR PROPERTIES OF A1100-SIZED GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Test Condition	Fiber Sizing	In-Plane Shear Strength (MPa)	(psi)	In-Plane Shear Modulus (GPa)	(10^6 psi)
22°C (72°F), Dry	A1100	65.6	9,520	4.38	0.635
22°C (72°F), Wet (2)	A1100	44.1	6,400	2.60	0.378
93°C (200°F), Wet (2)	A1100	25.8	3,740	0.90	0.131
22°C (72°F), Dry	Volan (3)	78.5	11,400	5.27	0.765
22C (72°F), Wet	Volan (3)	38.0	5,510	3.39	0.492
93°C (200°F), Wet	Volan (3)	18.9	2,740	1.67	0.243

(1) All values represent average of five specimens.
(2) WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
(3) The Volan sized fiber panels represent the baseline data.

TABLE 43

INTERLAMINAR SHEAR PROPERTIES OF A1100-SIZED GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Test Condition	Fiber Sizing	Interlaminar Shear Str. (MPa)	(psi)	Weight Gain During Aging (%)
22°C (72°F), Dry	A1100	42.4	6,150	N.A.
22C (72°F), Wet (2)	A1100	29.4	4,260	2.69%
93°C (200°F), Wet (2)	A1100	12.7	1,840	2.68%
22C (72°F), Dry	Volan (3)	38.7	5,620	N.A.
22°C (72°F), Wet	Volan (3)	20.5	2,980	2.18%
93°C (200°F), Wet	Volan (3)	11.8	1,710	2.15%

(1) All values represent average of five specimens. Four-point shear. Tested at 8:1 span-thickness ratio.
(2) WET = wet aged at 60°C (140°F)/100% R.H. until saturation.
(3) The volan sizing fiber panels represent the baseline data.

TABLE 44

EFFECT OF 177°C (350°F) CURE CYCLES ON INTERLAMINAR SHEAR STRENGTH OF EA9396 COMPOSITE LAMINATES

Reinforcement Type	Exposure Condition	Test Condition	Shear Strength(1,2) (MPa)	Shear Strength(1,2) (psi)	Weight Gain During Aging (%)
"E"-7781-Glass	None (3)	22°C (72°F), Dry	38.7	5620	N.A.
		93°C (200°F), Wet (4)	11.8	1710	2.15
	2 hrs. @ 177°C (350°F)	22°C (72°F), Dry	38.9	5650	N.A.
		93°C (200°F), Wet (4)	13.3	1930	2.04
	16 hrs. @ 177°C (350°F) (3 segments of 6 + 6 + 4 hrs)	22C (72°F), Dry	41.4	6010(5)	N.A.
		93°C (200°F), Wet (4)	13.2	1920(5)	2.25
T300-W133 Graphite	None (3)	22°C (72°F), Dry	39.3	5700	N.A.
		93°C (200°F), Wet (4)	16.1	2340	2.20
	2 hrs. @ 177°C (350°F)	22°C (72°F), Dry	34.5	5000	N.A.
		200°F, Wet (4)	13.7	1990	2.35
	16 hrs. @ 177°C (350°F) (3 segments of 6 + 6 + 4 hrs.)	22°C (72°F), Dry	36.2	5260	N.A.
		93°C (200°F), Wet (4)	13.2	1920	2.35

(1) Four-point shear (Graphite tests at 16:1 span-thickness ratio Glass tests at 8:1).
(2) Warp direction of fabric is running in length direction of specimens.
(3) The shear strength values listed for the no exposure condition represent the baseline interlaminar shear strengths.
(4) WET = aging at 60°C (140°F)/95-100% R.H. until saturated.
(5) These glass reinforced specimens turned very noticeably darker after this exposure. This darkening could not be noticed on the black graphite reinforced specimens.

TABLE 45

EFFECT OF RADIANT THERMAL PULSE ON COMPRESSION STRENGTH
OF GLASS-REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Data Source (1)	Test Condition (2)	Compression Strength	
		(MPa)	(psi)
Baseline Panel Average	22°C(72°F) Dry, No Pulse	281.6	40,840
Test Panel	22°C(72°F) Dry, No Pulse	293.7	42,600(3)
Test Panel	22°C(72°F) Dry, Pulsed	283.4	41,100
Baseline Panel Average	93°C(200°F) Dry, No Pulse	200.1	29,020
Test Panel	93°C(200°F) Dry, Pulsed	177.5	25,740
Baseline Panel Average	-54°C(-65°F) Wet, No Pulse	320.7	46,510
Test Panel	-54°C(-65°F) Wet, Pulsed	280.3	40,650
Baseline Panel Average	22°C(72°F) Wet, No Pulse	162.4	23,560
Test Panel	22°C(72°F) Wet, No Pulse	159.2	23,090(4)
Test Panel	22°C(72°F) Wet, Pulsed	146.8	21,290
Baseline Panel Average	93°C(200°F) Wet, No Pulse	97.8	14,180
Test Panel	93°C(200°F) Wet, Pulsed	70.7	10,250

NOTES:

1. Baseline panel average values from Tables 12 and 13. All test panel values represent an average of five specimens unless otherwise noted. Test panel, no pulse specimens were tested to demonstrate that the test panel was equivalent to the baseline panels.
2. The listed temperature represents the temperature at which the compression test was conducted. DRY means that the specimens were in the dry condition when exposed to thermal pulse (if applicable) and also when tested in compression. WET means that the specimens had been exposed to 60°C (140°F)/100% R.H. wet aging until saturated prior to the thermal pulse exposure (if applicable) and also when tested in compression. The wet aged samples that were thermally pulsed were reaged after the pulse until resaturated before being compression tested.
3. Average of two specimens.
4. Average of four specimens.

TABLE 46

EFFECT OF RADIANT THERMAL PULSE ON COMPRESSION STRENGTH
OF GRAPHITE-REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL

Data Source (1)	Test Condition (2)	Compression Strength	
		(MPa)	(psi)
Baseline Panel Average	22°C(72°F) Dry, No Pulse	420.3	60,960
Test Panel	22°C(72°F) Dry, No Pulse	448.2	65,000(3)
Test Panel	22°C(72°F) Dry, Pulsed	395.1	57,300
Baseline Panel Average	93°C(200°F) Dry, No Pulse	278.8	40,440
Test Panel	93°C(200°F) Dry, Pulsed	297.4	43,130
Baseline Panel Average	-54°C(-65°F) Wet, No Pulse	530.8	76,990
Test Panel	-54°C(-65°F) Wet, Pulsed	495.5	71,860
Baseline Panel Average	22°C(72°F) Wet, No Pulse	349.6	50,700
Test Panel	22°C(72°F) Wet, No Pulse	314.6	45,630(4)
Test Panel	22°C(72°F) Wet, Pulsed	315.1	45,690

NOTES:

1. Baseline panel average values from Tables 15 and 16. All test panel values represent an average of five specimens unless otherwise noted. Test panel, no pulse specimens were tested to demonstrate that the test panel was equivalent to the baseline panels.
2. The listed temperature represents the temperature at which the compression test was conducted. DRY means that the specimens were in the dry condition when exposed to thermal pulse (if applicable) and also when tested in compression. WET means that the specimens had been exposed to 60°C (140°F)/100% R.H. wet aging until saturated prior to the thermal pulse exposure (if applicable) and also when tested in compression. The wet aged samples that were thermally pulsed were reaged after the pulse until resaturated before being compression tested.
3. Average of two specimens.
4. Average of four specimens.

results of these tests. The data in these tables indicate that the laminates used in the thermal pulse tests were equivalent to the baseline laminates in the unpulsed condition and that exposure to a thermal pulse resulted in relatively small decreases in compression strength.

SECTION 4
CONCLUSIONS

Based on the results obtained during the test program described in this report, the following conclusions were drawn.

- Reproducible composite mechanical and physical property levels can be achieved using the wet-layup impregnation and vacuum-bag curing procedures described here.

- With vacuum-bag cure pressure, the void content of cured composites is in the vicinity of 5% by volume.

- Batch-to-batch property values are quite consistent and reproducible.

- Significant reductions in composite property levels occur with increasing temperature over the range of -65°F to 200°F.

- The property levels of EA9396 composites reinforced with a Volan-A sized glass fabric are significantly reduced when the composites become moisture saturated. A silane-type sizing on the glass reinforcement provides markedly better wet strength retention than the Volan-A type sizing and nearly equivalent to that of the graphite reinforced composites.

- Measurements made during this program indicate that nominally complete cure and peak property levels can only be achieved with elevated temperature (180°F and up) curing.

- The EA9396 resin system has a reasonable pot and work life at temperatures up to 100°F for use in repair.

- The EA9396 resin system appears to have good storage stability, even at elevated temperature.

- Exposure of EA9396 composites to simulated 350°F cure cycles had no adverse effect on mechanical properties.

- A high heat flux thermal pulse did not cause a major degradation in compressive strength levels.

SECTION 5
REFERENCES

1. Browning, C.E., Abrams, F.L., and Whitney, J.M., "A Four-Point Shear Test for Graphite/Epoxy Composites," Composite Materials: Quality Assurance and Processing, ASTM STP 7979, C.E. Browning, Ed., American Society for Testing and Materials, 1983, pp. 54-74.

2. MIL-HDBK-178, Polymer Matrix Composites, Vol. 1, Ch. 7, 29 February, 1988.

APPENDIX A
STANDARD LAMINATE PROCESSING PROCEDURE

Most of the laminates prepared during this investigation were made by a procedure designated the "Standard Procedure." This "Standard" laminate processing procedure is described below, first in a general stepwise listing of the procedure, and then in a more detailed description of each step. The general step-by-step procedure consisted of the following.

(a) Cut fabric (total number of plies = P).

(b) Weigh or measure the total area of all the plies cut in step (a).

(c) Compute total amount of resin needed to impregnate fabric cut in step (a), (see Table A.2).

(d) Weigh out and mix the total amount of resin needed. This is in the ratio of 100 parts A to 30 parts B by weight. A few grams extra should be allowed since some resin will adhere to sides of mixing container (total weight of mixed resin = W).

(e) Lay down first two plies of fabric, one atop the other.

(f) Weigh out an amount of mixed resin equal to 2.5 W/P. Pour this resin on top of the second ply and manually spread it over the entire surface as uniformly as possible.

(g) Lay down two more plies on top of the two in steps (e) and (f). Manually tamp these down so that the resin applied in step (f) is soaking into these two new plies.

(h) Weigh out an amount of mixed resin equal to 2 W/P. Pour this resin on top of the last ply and manually spread it over the entire surface as uniformly as possible.

(i) Do steps (g) and (h) a total of P-4/2 times.

(j) Lay down the last two plies of fabric on top of the previously impregnated plies.

(k) Lay down an amount of mixed resin equal to 1.5 W/P. Pour this resin on top of the last ply and manually spread it over the entire surface as uniformly as possible.

(l) Bag the layup in general accordance with Figure A.1.

(m) Cure the laminate in accordance with the standard cure cycle.

Each of the steps listed above, and the relevant rationale is described in detail below.

(a) The graphite (W133) and glass (7781) fabrics were cut to the size needed for the laminate being made. In this investigation, laminate sizes varied depending on the type and number of specimens that were required from the laminate. Table A.1 lists the thicknesses and dimensions used for the laminates prepared in this investigation.

(b) The amount of fabric used for each laminate was weighed. Alternatively, if a scale is not available, the total area of all the plies used for a laminate could be determined by measuring the dimensions of each ply.

(c) The amount of resin needed for the laminate being prepared depends on how much fabric needs to be impregnated. After some initial experimentation, we settled on using a 50% excess to provide for flow and bleed and to provide sufficient resin to allow uniform wet out of plies during the hand layup operation. Table A.2 lists the ratio of resin to fabric, on both a weight and area basis, that was used during laminate layup.

(d) Quantities of resin mixed for laminate preparation in this program ranged from around 50-60 grams for the smallest panels to 800-900 grams for the largest. In the case of the largest quantities, as many as three separate mixing containers were used (~300 grams each). This was done both to minimize the chance of a premature exotherm/gel and because larger mixing containers were not readily available. Between 5 and 10 grams of extra resin, beyond the quantities determined in step (c), were mixed in each mixing container to allow for the fact that some of the resin would be left behind on the container walls after impregnation.

(e) The actual impregnation process was performed on an 0.16 mm (0.063 inch) thick aluminum sheet coated with Frekote 44 release agent. Two dry plies of reinforcement were laid down atop one another on the aluminum sheet. Care was taken to keep track of the warp and fill direction of each ply of fabric so that the warp fibers were all aligned in the same direction for every ply. In addition, because both the W133 graphite and 7781 glass fabrics were 8-harness satin weaves, the predominant fiber direction on one side of the fabric was in the warp direction while on the other side it was in the fill direction. The plies were stacked such that the plies in the lower half of each laminate had the warp face down while the plies in the upper half had the warp face up. This ensured symmetry about the laminate midplane.

(f) The amount of resin poured onto the top of the first two plies laid down in step (e) was 2.5 W/P, where W represents the total weight of the resin computed and mixed in step (c) and P represents the total number of plies in the laminate being prepared. After addition of this resin to the first two plies, it was manually spread over the entire ply surface as uniformly as possible using a plastic spatula.

(g) This step is straightforward and requires no further elaboration.

(h) It will be noted that the amount of resin to be applied in this step (2 W/P) is less than the amount applied to the first two plies (2.5 W/P) in step (f). The reason for this is that since the intermediate plies pick up resin from the bottom, from previously impregnated plies, not as much resin needs to be added to these intermediate plies as to the first two plies, which do not pick up resin from below.

(i) The thinnest laminates made in this investigation were 8-ply except for those used as skins on honeycomb sandwich. For this case, steps (g) and (h) would be done a total of two times ([8-4]/2 = 2). For a 16-ply laminate, steps (g) and (h) would be done a total of six times. For a 4-ply laminate, steps (g) and (h) would not be done at all ([4-4]/2 = 0).

(j) This step is straightforward and requires no further elaboration.

(k) Again, it will be noted that the amount of resin applied in this step (1.5 W/P) is less than that applied in previous steps (f) and (h). The reason for this is that since these last two plies do not give up any resin to succeeding plies, but do gain resin from previously impregnated plies, not as much resin needs to be added to these top plies.

(l) In this investigation a Zip-Loc reusable vacuum bag system was used for laminate cure. The bleeder material used in the "standard" processing procedure being described here was Mochburg CW1850 (~71 gm/m^2). Table A.2 lists the number of bleeder plies that were used, relative to the number of plies of reinforcement in the laminate being cured. After completion of the layup and closing of the lid, the unit was placed in a circulating air oven, and a vacuum was drawn to verify that a good seal was present before heating commenced.

(m) The "standard cure cycle" consisted of curing the laminate for 45 minutes at 93°C (200°F) under vacuum pressure. The laminate was subjected to a nominal vacuum of 635 mm (25 inches) Hg before the oven was turned on. In the oven used, the

temperature of the circulating air reached 93°C (200°F) in approximately 3-4 minutes while the laminate in the vacuum bag reached 93°C (200°F) in about 50 minutes. Figure A.2 illustrates a typical heat-up curve for a lminate during a vacuum bag cure in the oven. The 45-minute cure period was started when the laminate temperature, as indicated by a thermocouple inside the vacuum bag, reached 90.5°C (195°F). At the conclusion of the 45-minute cure, the oven heaters were turned off, the door was opened, and the circulating air fan was left on. The vacuum was left on the laminate during cooldown. Cooldown time varied from as little as 1 hour to overnight, depending on time of day and oven schedule.

TABLE A.1

LAMINATE THICKNESSES AND DIMENSIONS

Type Test	Type Reinforcement			
	7781 Glass		W133 Graphite	
	Thickness(1)	Size Range (cm) [in]	Thickness(1)	Size Range (cm) [in]
Tension (D3039)	8 ply	max. (51 x 51) [20 x 20] min. (35.5 x 51) [14 x 20]	8 ply	(51 x 51) [20 x 20]
Compression (D3410B)	16 ply	max. (51 x 51) [20 x 20] min. (23 x 43) [9 x 17]	12 ply	max. (51 x 51) [20 x 20] min. (23 x 43) [9 x 17]
45° Tension/ Inplane Shear (D3418)	8 ply	max. (51 x 51) [20 x 20] min. (30.5 x 51) [12 x 20]	8 ply	max. (51 x 51) [20 x 20] min. (30.5 x 51) [12 x 20]
Interlaminar Shear (Four-Point Shear)	16 ply	max. (51 x 51) [20 x 20] min. (12.7 x 20.3) [5 x 8]	12 ply	max. (30.5 x 30.5) [12 x 12] min. (12.7 x 20.3) [5 x 8]
Bearing (MIL-HDBK-17)	8 ply	(30.5 x 35.5) [12 x 14]	8 ply	(30.5 x 35.5) [12 x 14]
Flatwise Tension (2) (C297)	---	---	2 ply	(15.2 x 15.2) [6 x 6]
Edgewise Compression (2) (C364)	4 ply	(3.3 x 35.5) [13 x 14]	2 ply	(33 x 35.5) [13 x 14]

TABLE A.2

EA9396 BASELINE LAMINATE FABRICATION PARAMETERS

Parameter	Reinforcement Type W133 Gr Fabric	7781 Gl Fabric
Grams of Mixed Resin Per Gram of Reinforcement Used During Impregnation	0.755	0.555
-or-		
Grams of Mixed Resin Per Unit Area of Reinforcement(1) Used During Impregnation	0.178 gm/in^2 0.0276 gm/cm^2	0.104 gm/in^2 0.0161 gm/cm^2
Plies of Mochburg CW1850 Bleeder (71 gm/m^2) Per Ply of Reinforcement	0.40(2)	0.25(2)
Cure Schedule	45 minutes at 93°C (200°F) under vacuum pressure (~125 mm Hg abs. pressure) (~25 inch Hg vac.)	

(1) Total area of all reinforcement plies, not area of laminate. The values listed correspond to the mass/mass ratios listed directly above for the respective graphite and glass fabrics used. These two reinforcing fabrics are described in Table 1 and have the following weight per unit areas:

W133 - 0.236 gm/in^2
7781 - 0.190 gm/in^2

(2) Round off to the next higher whole number if the calculated number of bleeder plies is a fraction.

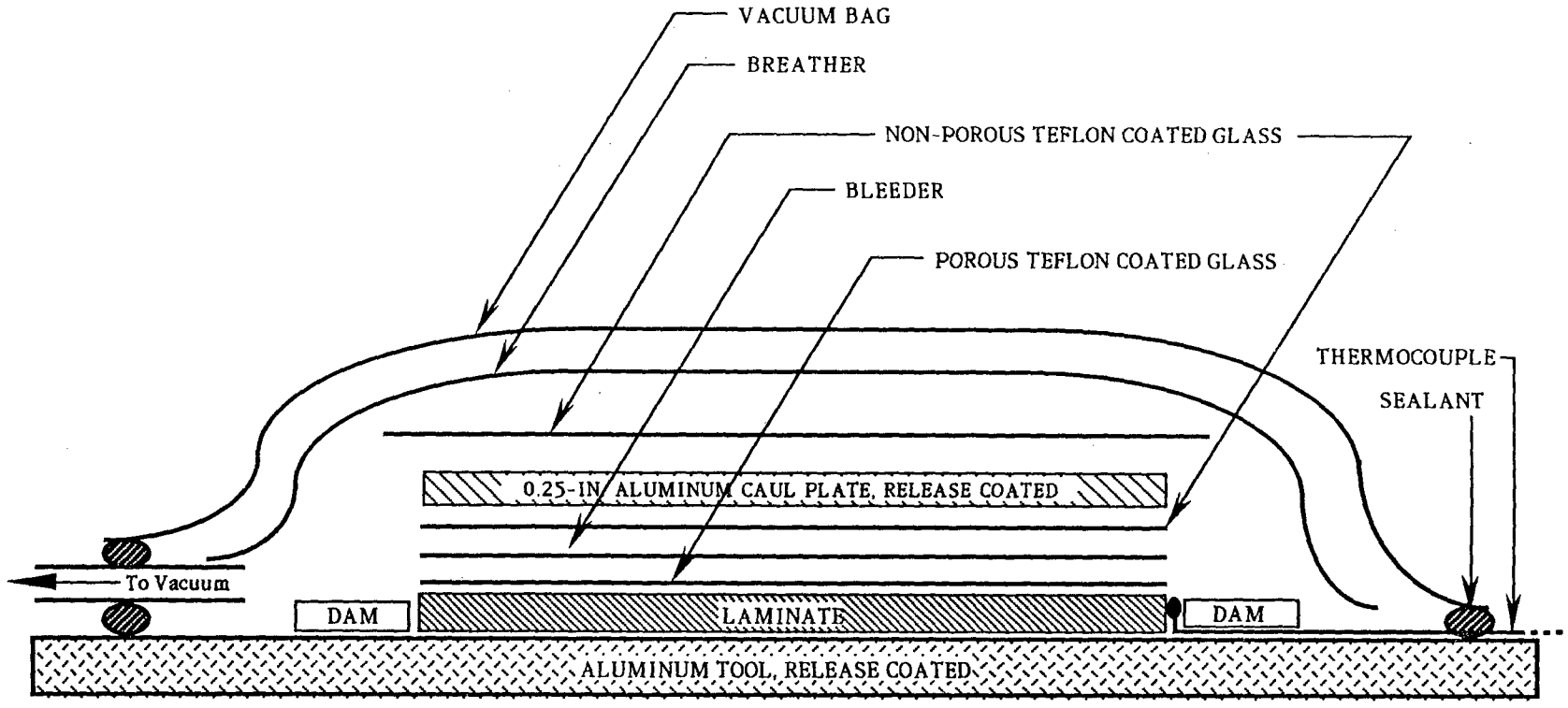


Figure A.1. Typical Vacuum Bag Layup Scheme for Curing EA9396 Composite Laminates.

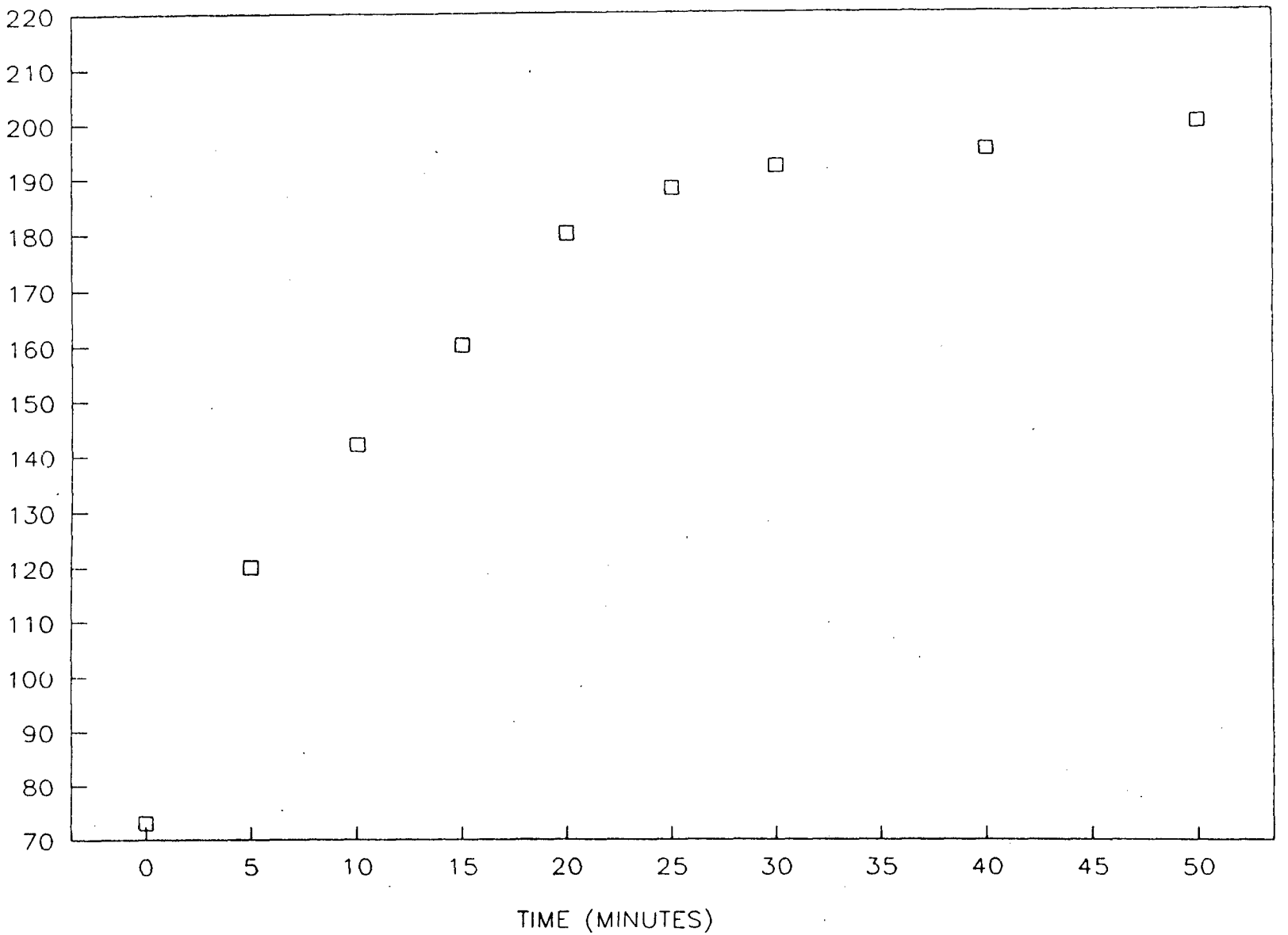


Figure A.2. Heat-Up Curve for Laminate Cure.

APPENDIX B
NONSTANDARD LAMINATE PROCESSING PROCEDURES

Quite a few laminates prepared during this investigation were not made in accordance with the "Standard Procedure" described in Appendix A. The processing procedures for these nonstandard laminates were varied in order to determine the effect of processing variations that might occur in field repair situations on resulting mechanical and physical laminate properties.

The processing variations described in this Appendix are subdivided into six categories and each is addressed respectively in Sections B.1-B.6.

B.1 NONSTANDARD CURE TIME/TEMPERATURE

In Section 3.5.2, the effect of cure time and temperature on interlaminar shear strength was discussed. Five graphite reinforced laminates were prepared using different cure conditions than those described in step (m) of Appendix A. Except for this difference in cure condition, all five of these laminates were prepared in accordance with the "Standard Procedure" described in Appendix A. Table B.1 identifies the five laminates cured at alternative times/temperatures and lists the time/temperature history used for each.

B.2 NONSTANDARD CURE VACUUM PRESSURES

In Section 3.5.3, the effect of vacuum bag vacuum pressure level during cure on interlaminar shear strength was discussed. Four glass reinforced laminates were prepared using different vacuum pressure levels than that noted in step (m) of Appendix A. Except for this difference in vacuum pressure level, all four of these laminates were prepared in accordance with the "Standard Procedure" described in Appendix A. Table B.2 identifies the four laminates cured under alternate vacuum pressure levels and lists the vacuum level used.

B.3 NONSTANDARD FIBER CONTENT

In Section 3.8, the effect of fiber content on mechanical properties was discussed. Both glass and graphite fabric reinforced laminates were prepared with fiber contents ranging from the standard 55% by volume down to as low as 34% by volume. All these low fiber content laminates were cured by the "Standard" cure cycle described in step

(m) of Appendix A. The differences in fiber content were achieved by changing either the bleeder ply/reinforcement ply ratio used during cure, or the ratio of resin to reinforcement used during impregnation. Other than these differences, the laminate processing was identical to that described in Appendix A. Table B.3 identifies the laminates for which either the bleeder or resin ratios were varied and lists the particular details for each.

B.4 NONSTANDARD PLY IMPREGNATION PROCEDURES

Section 3.9.1 discusses alternative ply impregnation procedures that were investigated. The two alternate impregnation procedures that were investigated were felt to be representative of procedures that might be employed by repair personnel working in the field.

Laminate No. BIL-GL-14

The first variation consisted of applying resin to every ply instead of every other ply, as in the "Standard Procedure" described in Appendix A. The difference between this nonstandard procedure and the standard procedure was in steps (e)-(j) of Appendix A. Instead of the procedure described in steps (e)-(j) the procedure outlined below was followed.

(e) Lay down the first ply of fabric.
(f) Weigh out an amount of mixed resin equal to W/P. Pour this resin on top of the first ply and manually spread it over the entire surface as uniformly as possible.
(g) Do steps (e) and (f) a total of P times.

After step (g) was completed, the procedure reverted to steps (l) and (m) of Appendix A.

Laminate No. BIL-GL-16

The second variation consisted of using a smaller quantity of resin during impregnation of the reinforcement than the 50% excess used in the "Standard Procedure" described in Appendix A. This smaller quantity of resin represented 0% excess (net resin content). Further, since no excess resin was used, no bleeder plies were used during cure.

Thus the differences between the "Standard Procedure" described in Appendix A, and that used for this laminate, occurred in step (c) (and by reference, Table A.2) and in step (l) (and by reference, Figure A.1). The resin ratio used for glass reinforced laminates in the "Standard Procedure" was 0.555 gm resin/gm reinforcement. In laminate BIL-GL-16, the ratio was 0.377 instead. In addition, the bleeder ratio used for glass reinforced laminates in the "Standard Procedure" was 0.25 plies of bleeder/ply reinforcement (Table A.2). In laminate BIL-GL-16, no bleeder plies were used at all.

B.5 NONSTANDARD BLEEDER MATERIAL

Section 3.9.2 discusses the use of alternative bleeder materials to the Mochburg CW1850 bleeder used in the "Standard Procedure" of Appendix A. Three glass and two graphite reinforced laminates were prepared using alternative bleeder material. The three glass laminates were made using the E-7781 glass fabric as bleeder while the two graphite laminates were made using the T300-W133 graphite fabric as bleeder. Other than this difference in bleeder material, the laminate processing was identical to the "Standard Procedure" described in Appendix A. Table B.4 identifies the laminates made with the nonstandard bleeder material, the applicable bleeder ratios that were used, and the resin absorption characteristics of the alternative materials.

B.6 NONSTANDARD BAGGING SCHEMES

Section 3.9.3 discusses the investigation of several laminate bagging schemes that varied from the standard scheme illustrated in Figure A.1. The goal of each of these variant bagging schemes was to improve laminate quality by reducing void content below that normally resulting from a vacuum bag cure (see Table 4). The two variant bagging schemes described in this section were felt to be readily usable in the field. Each is discussed separately below.

Perforated Barrier Film

The first approach was to perforate the normally non-porous barrier between the bleeder material and the breather material. It will be observed in Figure A.1 that in the standard bagging scheme, this nonporous barrier consists of a caul plate sandwiched between two sheets of nonporous teflon-coated glass. The purpose of the teflon-coated glass is to keep excess resin absorbed in the bleeder plies from being absorbed into the breather, where it might clog the vacuum paths and prevent full vacuum pressure from being uniformly exerted on the laminate surface. The purpose of the caul plate is to

prevent inadvertent wrinkles that may develop in the vacuum bag from imprinting the laminate surface and to prevent the vacuum bag from drawing down more tighly around the laminate edges than in the center, thereby producing nonuniform thickness. In the modified bagging scheme, the two layers of nonporous teflon-coated glass and the caul plate were replaced by a single layer of the teflon-coated glass that had been perforated with a series of knife slits. Figure B.1 illustrates this bagging scheme.

The rationale for investigating this type of bagging scheme was that perforations in the film between the bleeder and breather materials would permit the vacuum to draw air out of the bleeder instead of forcing it into the laminate layup. It was speculated that air might be trapped in the bleeder when the vacuum was applied because the caul plate would be pressed down so tightly that air escape paths would be shut off.

Other than the altered bagging scheme illustrated in Figure B.1, the processing of the laminate made with this procedure, BIL-GL-39, was identical to the "Standard Procedure" described in Appendix A.

Double-Bag

The second nonstandard bagging scheme that was investigated was the use of a double vacuum bag rather than the single bag scheme illustrated in Figure A.1. The rationale for this was that while the vacuum applied in the single bag scheme supposedly aids in drawing air and volatiles out of the laminate, the compaction of the layup resulting from the vacuum bag may pinch off escape paths and trap air and volatiles in the layup. The idea of a double bag scheme is that this approach permits the layup to "breathe" even while under vacuum by reducing the compacting force during the early part of the cure cycle. The double bag arrangement is illustrated in Figure B.2. An essential element of this arrangement is the "hardback" shell that holds the outer vacuum bag off the inner vacuum bag, thereby allowing the compacting force on the layup to be reduced during the early part of the cure cycle while simultaneously imposing a vacuum on the layup to draw off air and volatiles.

In using the bagging scheme illustrated in Figure B.2, a different cure cycle than that described in step (m) of Appendix A was followed. The cure cycle for the double-bag cure was as follows:

1. Draw a vacuum (23-24 in Hg) on the shell (#2).

2. Draw a vacuum (~25 in Hg) on the inner bag (#1).

3. Hold these two vacuum levels for 30 minutes at 22°C (72°F).

4. Vent line #2 to the atmosphere while maintaining full vacuum (~25+ in. Hg) on line #1.

5. Heat to 93°C (200°F).

6. When the temperature in the inner bag reaches 91°C (195°F), start a 45-minute hold, maintaining full vacuum on line #1.

7. Cool to 49°C (120°F) or less while maintaining full vacuum on line #1.

8. Remove.

TABLE B.1

LAMINATES CURED AT NONSTANDARD TIMES/TEMPERATURES

Laminate Number	Cure Temperature (°C)	Cure Temperature (°F)	Cure Time
"STANDARD"	93	200	45 minutes under vacuum
BIL-GR-5	107	225	45 minutes under vacuum
BIL-GR-1	93	200	30 minutes under vacuum
BIL-H7-5	82	180	30 minutes under vacuum
BIL-GR-4R	79	175	45 minutes under vacuum
BIL-GR-20	22	72	4 hours under vacuum + 7 days at ambient conditions + 3 months in either dry ambient storage or in 60°C (140°F), 95-100% R.H. humidity cabinet

TABLE B.2

LAMINATES CURED UNDER NONSTANDARD VACUUM PRESSURE

Laminate Number	Vacuum Bag Pressure Level During Cure (mm Hg Vacuum)	Vacuum Bag Pressure Level During Cure (in. Hg Vacuum)
"STANDARD"	635	25
BIL-GL-27	254	10
BIL-GL-28	406	16
BIL-GL-29	584	23
BIL-GL-38	686	27

TABLE B.3

LAMINATES PREPARED WITH NONSTANDARD BLEEDER PLY IN RESIN RATIOS

Laminate Number	Bleeder Ply/Reinforcement Ply Ratio (1) (plies bleeder/ply reinforcement)	Resin/Reinforcement Ratio (1) (gm resin/ gm reinforcement)
GRAPHITE		
"Standard"	0.40	0.755
BIL-GR-51	0.42	0.548
BIL-GR-52	0.42	0.787
BIL-GR-53	0.33	1.000
BIL-GR-54	0.25	1.160
BIL-GR-79	0	1.150
BIL-GR-84	0.083	1.115
GLASS		
"Standard"	0.25	0.555
BIL-GL-10	0.25	0.755
BIL-GL-31	0.375	0.555
BIL-GL-33	0.25	0.706
BIL-GL-53	0	1.000
BIL-GL-54	0.125	1.000

NOTE:

(1) See Table A.2 (Appendix A) for baseline laminate fabrication parameters.

TABLE B.4

LAMINATES MADE WITH NONSTANDARD BLEEDER MATERIAL

Laminate Number	Bleeder Material	Bleeder Dry Area Density (gm/m^2)	Bleeder/ Laminate Ply Ratio	Bleeder Absorptivity		Bleeder Ply Equivalents (8)
				(gm/gm) (6)	(gm/cm^2) (7)	
GLASS "Standard"	CW1850	71	0.25 (1)	3	0.0213	1.0
BIL-GL-17	E-7781 fabric	295	0.25 (2)	0.50	0.0147	1.51-1.88
BIL-GL-37	E-7781 fabric	295	0.118 (3)	0.39-0.42	0.0112-0.0124	1.51-1.88
BIL-GL-47	E-7781 fabric	295	0.375 (4)	0.41	0.0121	1.51-1.88
GRAPHITE "Standard"	CW1850	71	0.40 (1)	3	0.0213	1.0
BIL-GR-58	T300-W133 fabric	366	0.25 (5)	0.58	0.0197	1.13-1.30
BIL-GR-64R	T300-W133 fabric	366	0.375 (4)	0.47	0.0171	1.13-1.30

NOTES:

(1) From Table A.2, Appendix A.
(2) Two plies bleeder, eight plies reinforcement.
(3) Three plies bleeder, sixteen plies reinforcement.
(4) Three plies bleeder, eight plies reinforcement.
(5) Three plies bleeder, twelve plies reinforcement.
(6) Grams resin absorbed per gram of bleeder. Value for CW1850 represents average for all baseline laminates.
(7) Grams resin abosrbed per unit area of bleeder. Value for CW1850 represents average for all baseline laminates.
(8) Number of plies needed to absorb some quantity of resin as one ply of Mochburg CW1850.

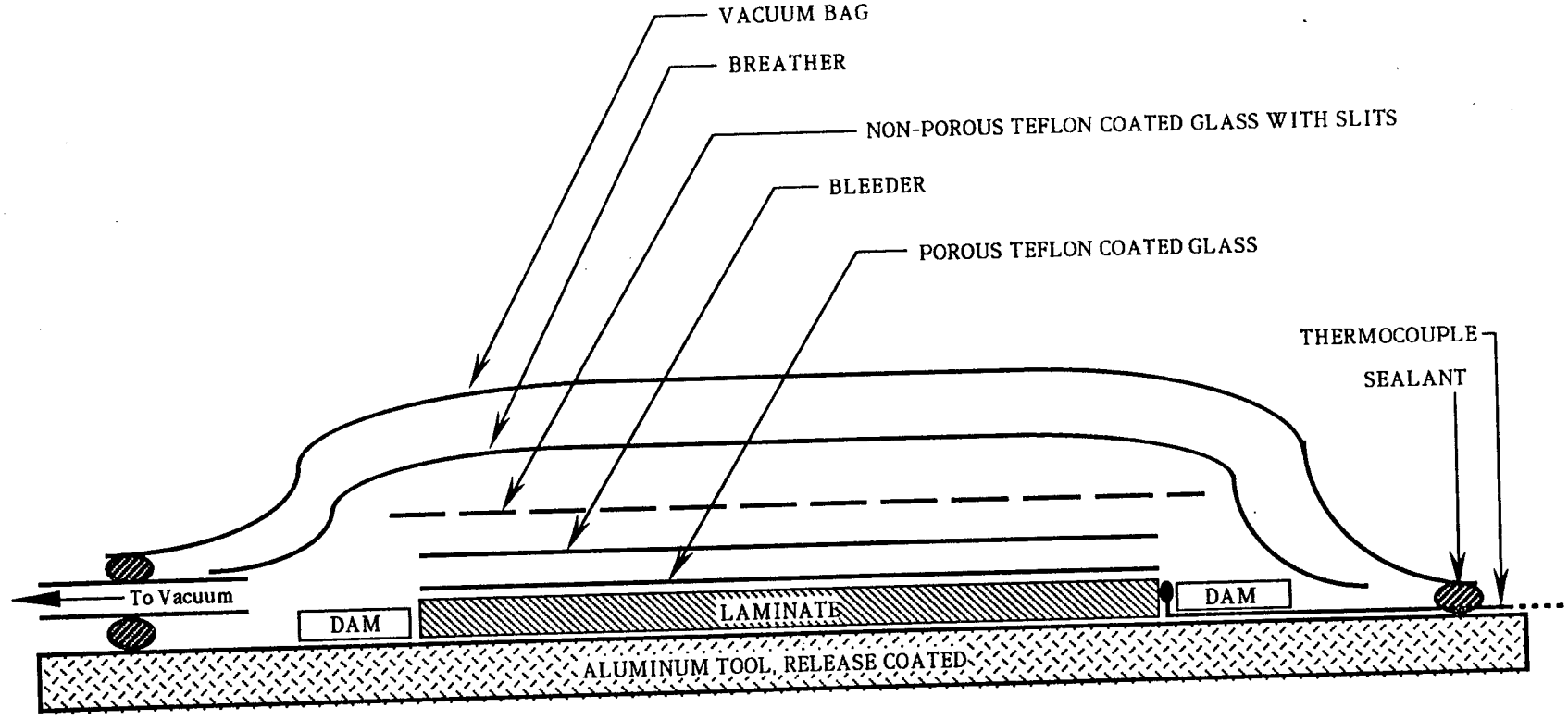


Figure B.1. Nonstandard Vacuum Bag Lay-up Scheme with Perforated Bleeder/Breather Barrier Film.

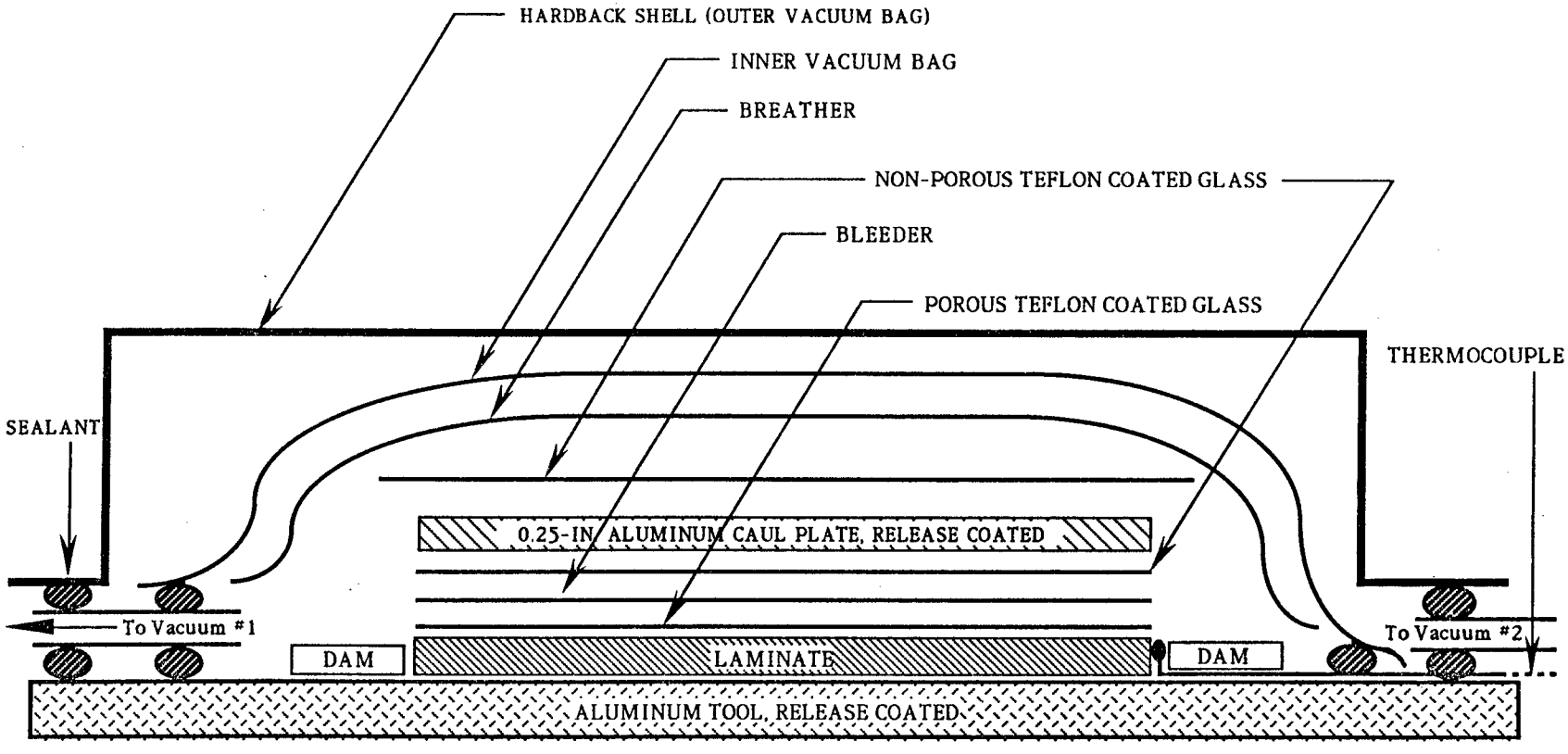


Figure B.2. Nonstandard Vacuum Bag Lay-up Using Double-Bag Scheme.

APPENDIX C
LAMINATE PHYSICAL PROPERTIES

The laminate physical properties for all of the glass and graphite reinforced laminates prepared and evaluated during this investigation are listed in this Appendix. Each property value listed represents an average of three replicate determinations from various locations within the same laminate.

The data are organized generally as follows:

Baseline Laminates
Laminates Processed at Nonbaseline Temperatures or Pressures
Laminates Prepared from Stored Resin
Laminates Prepared with Variable Fiber Content
Laminates Prepared with Alternate Impregnation and Bagging Schemes
Laminates Prepared with Silane Sized Glass Reinforcement
Laminates Prepared for Nonbaseline Environmental Exposure

This sequence corresponds to the sequence in which these various types of laminate, processing and test variables are discussed in Section 3 of the text.

The laminate number listed in the first column of Tables C.1 (graphite reinforced laminates) and C.2 (glass reinforced laminates) corresponds to the individual specimen numbering system that appears in the appendices to follow.

TABLE C.1

PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
FABRIC REINFORCED LAMINATES

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-7	8	Tension	Baseline (App. A)	1.49	0.39	15.3	56.3	34.2	4.0
BIL-GR-8	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.6	4.5
BIL-GR-9	8	Tension	Baseline (App. A)	1.48	0.39	15.2	57.3	32.7	4.5
BIL-GR-10	8	Tension	Baseline (App. A)	1.48	0.38	14.8	56.6	33.3	4.8
BIL-GR-11	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.8	4.1
BIL-GR-12	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.8	4.2
BIL-GR-13	12	Compression	Baseline (App. A)	1.47	0.38	15.0	55.5	34.7	4.3
BIL-GR-14	12	Compression	Baseline (App. A)	1.49	0.39	15.2	53.7	37.1	2.8
BIL-GR-15	12	Compression	Baseline (App. A)	1.48	0.37	14.7	55.5	34.7	4.3
BIL-GR-16	12	Compression	Baseline (App. A)	1.47	0.38	15.0	54.9	34.9	4.8
BIL-GR-37	8	Inplane Shear	Baseline (App. A)	1.50	0.39	15.3	56.0	33.4	4.6
BIL-GR-38	8	Inplane Shear	Baseline (App. A)	1.48	0.39	15.2	53.9	35.4	4.7
BIL-GR-39	8	Inplane Shear	Baseline (App. A)	1.49	0.39	15.2	56.1	33.0	5.6
BIL-GR-40	8	Inplane Shear	Baseline (App. A)	1.48	0.41	16.0	56.6	32.8	4.8
BIL-GR-41	8	Inplane Shear	Baseline (App. A)	1.49	0.38	15.0	57.0	31.9	5.5
BIL-GR-42	8	Inplane Shear	Baseline (App. A)	1.49	0.39	15.2	56.9	32.1	5.5
BIL-GR-17	12	Interlaminar Shear	Baseline (App. A)	1.48	0.37	14.6	54.6	35.6	4.0
BIL-GR-18	12	Interlaminar Shear	Baseline (App. A)	1.47	0.38	14.9	54.8	33.9	5.9
BIL-GR-19	12	Interlaminar Shear	Baseline (App. A)	1.48	0.37	14.5	55.9	32.6	6.2
BIL-GR-43	8	Bearing	Baseline (App. A)	1.49	0.38	15.1	55.6	33.6	5.2
BIL-GR-1	12	ILS, Effect of Cure	Appendix B.1	1.48	0.38	15.0	58.1	30.2	5.4
BIL-GR-4R	12	Time/Temp.		1.47	0.37	14.4	56.2	32.2	5.3
BIL-GR-5	12			1.48	0.36	14.3	55.2	33.0	4.5
BIL-GR-20	12			1.48	0.37	14.6	58.5	31.3	5.3
BIL-H7-5	12			1.50	0.36	14.0	56.8	32.7	4.5
Average (Baseline Process Only, 20 Laminates)				1.48	0.38	15.1	55.8	33.9	4.7
Standard Deviation				0.01	0.01	0.3	1.0	1.3	0.8

TABLE C.1

PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
FABRIC REINFORCED LAMINATES (Continued)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-2	12	ILS; Effect of Storage; 1 month @ 38°C (100°F)	Baseline (App. A)	1.48	0.36	14.3	55.5	33.2	4.9
BIL-GR-3	12	1 month @ 49°C (120°F)		1.45	0.37	14.6	55.6	31.9	6.6
BIL-GR-6	12	1 month @ 22°C (72°F)		1.47	0.36	14.0	56.4	32.2	5.3
BIL-GR-30	12	3 months @ 22°C (72°F)		1.48	0.36	14.0	60.6	28.6	6.2
BIL-GR-47	12	6 months @ 49°C (120°F)		1.45	0.42	16.6	50.6	37.9	6.0
BIL-GR-48	12	6 months @ 38°C (100°F)		1.47	0.41	16.3	52.2	36.8	5.2
BIL-GR-49	12	6 months @ 22°C (72°F)		1.46	0.42	16.4	52.1	36.7	5.6
BIL-GR-59	12	12 months @ 38°C(100°F)		1.47	0.37	14.5	55.8	32.2	7.0
BIL-GR-60	12	12 months @ 22°C (72°F)		1.48	0.37	14.7	55.7	32.8	6.2
BIL-GR-61	12	12 months @ 49°C(120°F)		1.47	0.37	14.7	54.6	34.0	6.1
BIL-GR-72	12	18 months @ 49°C(120°F)		1.46	0.38	14.8	52.3	36.2	6.1
BIL-GR-73	12	18 months @ 38°C(100°F)		1.47	0.37	14.7	53.4	35.5	5.4
BIL-GR-74	12	18 months @ 22°C (72°F)		1.49	0.38	14.9	56.0	33.3	4.9
BIL-GR-85	12	24 months @ 22°C (72°F)		1.49	0.38	14.9	54.3	35.1	4.6
BIL-GR-86	12	24 months @ 38°C(100°F)		1.48	0.40	15.6	53.5	35.6	5.1
BIL-GR-87	12	24 months @ 49°C(120°F)		1.48	0.39	15.4	52.9	36.2	5.1
BIL-GR-89	12	43 months @ 22°C (72°F)		1.50	0.35	13.8	57.0	32.5	4.6
BIL-GR-90	12	43 months @ 38°C(100°F)		1.50	0.36	14.2	56.8	32.8	4.4
BIL-GR-91	12	50 months @ 22°C (72°F)		1.44	0.38	14.8	53.1	34.0	8.4

TABLE C.1

PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
FABRIC REINFORCED LAMINATES (Concluded)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-51	12	ILS; Effect of Fiber Content	Appendix B.3	1.47	0.37	14.5	55.8	32.5	6.5
BIL-GR-52	12			1.47	0.37	14.7	54.7	33.6	6.4
BIL-GR-53	12			1.46	0.40	15.7	50.1	39.0	4.9
BIL-GR-54	12			1.47	0.40	15.8	49.8	39.0	4.7
BIL-GR-79	12	Compression; Effect of	Appendix B.3	1.41	0.52	20.6	40.5	48.8	5.5
BIL-GR-84	12	Fiber Content	Appendix B.3	1.39	0.51	19.9	42.3	45.6	7.5
BIL-GR-58	12	Check Alternate Bleeder	Appendix B.5	1.48	0.37	14.4	55.4	33.1	5.8
BIL-GR-64R	8	Material		1.49	0.39	15.4	53.5	36.0	4.5
BIL-GR-63R	12	Check Alternate Bagging Scheme	Appendix B.6	1.48	0.40	15.7	55.0	33.6	5.9
BIL-GR-50	12	Compression After Thermal Pulse	Baseline (App. A)	1.47	0.41	16.3	53.6	35.3	5.5

NOTES: 1. ILS = Interlaminar Shear

TABLE C.2

PHYSICAL PROPERTIES OF E-7781 GLASS
FABRIC REINFORCED LAMINATES

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GL-1R	8	Tension	Baseline (App. A)	1.92	0.22	8.5	55.8	25.9	5.1
BIL-GL-2R	8	Tension	Baseline (App. A)	1.94	0.22	8.5	56.5	25.9	3.9
BIL-GL-3	8	Tension	Baseline (App. A)	1.93	0.2	8.6	55.3	27.0	3.7
BIL-GL-4	8	Tension	Baseline (App. A)	1.91	0.22	8.5	54.1	27.7	4.1
BIL-GL-5	8	Tension	Baseline (App. A)	1.92	0.22	8.6	55.7	26.0	5.0
BIL-GL-6	8	Tension	Baseline (App. A)	1.89	0.22	8.6	54.0	27.2	5.4
BIL-GL-7	16	Compression	Baseline (App. A)	1.90	0.21	8.3	53.7	27.9	4.5
BIL-GL-8	16	Compression	Baseline (App. A)	1.90	0.22	8.6	53.6	28.2	4.2
BIL-GL-9	16	Compression	Baseline (App. A)	1.89	0.22	8.6	53.8	27.6	5.0
BIL-GL-10R	16	Compression	Baseline (App. A)	1.87	0.22	8.6	51.2	30.4	4.0
BIL-GL-18	8	Inplane Shear	Baseline (App. A)	1.92	0.21	8.4	56.5	25.1	5.5
BIL-GL-19R	8	Inplane Shear	Baseline (App. A)	1.92	0.22	8.7	54.5	27.7	3.6
BIL-GL-20R	8	Inplane Shear	Baseline (App. A)	1.92	0.21	8.3	56.5	25.0	5.7
BIL-GL-21	8	Inplane Shear	Baseline (App. A)	1.94	0.22	8.5	56.9	25.2	4.6
BIL-GL-23R	8	Inplane Shear	Baseline (App. A)	1.89	0.20	7.9	54.2	27.0	5.5
BIL-GL-24	8	Inplane Shear	Baseline (App. A)	1.93	0.22	8.5	56.8	25.0	4.9
BIL-GL-11	16	Interlaminar Shear	Baseline (App. A)	1.88	0.21	8.3	55.0	25.5	7.2
BIL-GL-12	16	Interlaminar Shear	Baseline (App. A)	1.88	0.21	8.3	54.9	25.5	7.4
BIL-GL-13R	16	Interlaminar Shear	Baseline (App. A)	1.87	0.21	8.4	54.0	26.5	6.9
BIL-GL-22	8	Bearing	Baseline (App. A)	1.96	0.20	8.0	57.4	25.2	3.7
BIL-GL-27	16	ILS; Effect of Cure	Appendix B.2	1.87	0.22	8.5	52.6	28.6	5.4
BIL-GL-28	16	Vacuum Pressure		1.88	0.21	8.1	55.0	25.6	7.1
BIL-GL-29	16			1.91	0.21	8.1	56.6	24.4	6.7
BIL-GL-38	16			1.94	0.19	7.6	56.1	26.2	3.9
BIL-GL-10	16	ILS; Effect of Fiber Content	Appendix B.3	1.79	0.25	10.0	45.6	35.2	4.7
BIL-GL-30	16			1.89	0.22	8.5	54.3	26.7	6.1
BIL-GL-31	16			1.94	0.22	8.5	55.4	26.2	5.0
BIL-GL-33	16			1.86	0.23	9.2	52.3	28.4	6.4
BIL-GL-53	16	Compression; Effect of	Appendix B.3	1.59	0.36	14.3	33.9	45.6	9.3
BIL-GL-54	16	Fiber Content		1.62	0.31	12.1	35.8	43.6	8.8
Average (Baseline Process Only, 20 Laminates)				1.91	0.22	8.5	55.0	26.6	5.0
Standard Deviation				0.03	0.005	0.2	1.5	1.4	1.1

TABLE C.2

PHYSICAL PROPERTIES OF E-7781 GLASS
FABRIC REINFORCED LAMINATES (Concluded)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GL-17	8	Check Alternate Bleeder Material	Appendix B.5	1.85	0.21	8.2	49.5	31.6	4.5
BIL-GL-37	16			1.84	0.20	7.8	50.0	30.7	5.6
BIL-GL-47	8			1.89	0.23	8.9	52.5	29.2	4.2
BIL-GL-39	16	Check Alternate Bagging Scheme	Appendix B.6	1.86	0.20	7.7	52.8	27.6	6.7
BIL-GL-14	8	Check Alternate Impregnation Scheme	Appendix B.4	1.87	0.21	8.1	52.6	28.4	5.9
BIL-GL-16	8			1.85	0.20	7.9	50.3	30.8	4.8
BIL-GL-44	8	Tension	Baseline (App. A)	1.85	0.23	8.9	53.7	25.9	8.5
BIL-GL-45	16	Interlaminar Shear	Baseline (App. A)	1.83	0.23	8.9	52.6	26.8	8.9
BIL-GL-46	8	Inplane Shear; Effect of Silane Sizing	Baseline (App. A)	1.88	0.22	8.6	53.6	27.2	6.3
BIL-GL-25	16	Compression After Thermal Pulse	Baseline (App. A)	1.91	0.23	9.0	56.5	24.4	6.8

NOTES: 1. ILS = Interlaminar Shear

APPENDIX D
INDIVIDUAL SPECIMEN TENSION PROPERTIES, BASELINE

The 48 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in tension. A summary of these data was presented and discussed in Section 3.2.1.

TABLE D.1

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass				Batch #1	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1R-17	72°F (DRY)	1.005	0.0677	3,725	54.76	3.653	18,960	0.128	5/3/89	(2,3,5)
BIL-GL-1R-19	"	1.004	0.0685	3,589	52.18	3.660	17,475		5/2/89	(2,3,4)
BIL-GL-1R-21	"	1.002	0.0656	3,429	52.16	3.667	16,950		"	(2,3,4)
BIL-GL-1R-18	"	1.001	0.0671	3,464	51.57	3.535	17,670	0.114	5/3/89	(1,3,5)
BIL-GL-1R-20	"	0.996	0.0694	3,321	48.03	3.486	16,350		5/2/89	(2,3,4)
			Average		51.74	3.600	17,481	0.121		
			Std. Dev.		2.41	0.084	973	0.010		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" gage length axial extensometer.
(5) 2.00" gage length biaxial extensometer.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
377.6	25.19	18,960
359.8	25.24	17,475
359.6	25.28	16,950
355.6	24.38	17,670
331.2	24.03	16,350
Average	356.7	24.82	17,481
Std. Dev.	16.6	0.58	973

TABLE D.2

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-17	72°F (DRY)	1.000	0.0683	3,954	57.89	3.713	19,130	0.104	5/11/89	(1,2,3,4)
BIL-GL-5-19	"	1.004	0.0682	3,821	55.83	3.731	21,750		"	(1,2,3,5)
BIL-GL-5-21	"	1.003	0.0671	3,554	52.79	3.767	17,250		"	(1,2,3,5)
BIL-GL-6-18	"	1.001	0.0694	3,439	49.49	3.649	16,580		"	(1,2,3,5)
BIL-GL-6-20	"	1.004	0.0693	3,564	51.22	3.541	17,850	0.116	"	(1,2,3,4)
			Average		53.44	3.680	18,512	0.110		
			Std. Dev.		3.41	0.088	2,039	0.009		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	399.2	25.60	19,130
	385.0	25.72	21,750
	364.0	25.97	17,250
	341.3	25.16	16,580
	353.2	24.42	17,850
Average	368.5	25.37	18,512
Std. Dev.	23.5	0.61	2,039

TABLE D.3

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass				Batch #3	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-17	72°F (DRY)	1.007	0.0686	3,493	50.57	3.619	16,980	0.123	5/10/89	(1,2,3,4)
BIL-GL-3-19	"	0.999	0.0688	3,464	50.42	3.613	17,250		"	(1,2,3,5)
BIL-GL-3-21	"	1.000	0.0699	3,429	49.07	3.451	17,160		"	(1,2,3,5)
BIL-GL-4-18	"	0.994	0.0689	3,393	49.53	3.571	18,150		"	(1,2,3,5)
BIL-GL-4-20	"	1.003	0.0676	3,446	50.85	3.662	16,650	0.106	"	(1,2,3,4)
			Average		50.09	3.583	17,238	0.114		
			Std. Dev.		0.75	0.081	559	0.011		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	348.7	24.96	16,980
	347.7	24.91	17,250
	338.4	23.79	17,160
	341.5	24.63	18,150
	350.6	25.25	16,650
Average	345.4	24.71	17,238
Std. Dev.	5.2	0.56	559

TABLE D.4

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass				Batch #1	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-18	72°F (WET)	1.004	0.0713	1,144	15.99	3.187	5,068	0.072	8/22/89	(2,3,4,6)
BIL-GL-1(R)-20	"	1.003	0.0716	1,193	16.62	3.176	5,313		"	(2,3,5,6)
BIL-GL-1(R)-17	"	1.005	0.0706	1,250	17.62	3.153	5,850		"	(2,3,5,6)
BIL-GL-1(R)-19	"	1.004	0.0713	1,106	15.46	3.329	4,688	0.085	8/21/89	(2,3,4,6)
BIL-GL-1(R)-21	"	1.004	0.0708	1,159	16.30	3.067	5,498	0.061	8/22/89	(2,3,4,6)
			Average		16.40	3.182	5,283	0.073		
			Std. Dev.		0.81	0.095	438	0.012		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
110.2	21.98	5,068
114.6	21.90	5,313
121.5	21.74	5,850
106.6	22.95	4,688
112.4	21.15	5,498
Average 113.1	21.94	5,283
Std. Dev. 5.6	0.65	438

TABLE D.5

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-18	72°F (WET)	1.007	0.0710	1,197	16.74	3.343	5,210	0.086	8/22/89	(2,3,4,6)
BIL-GL-5-20	"	1.007	0.0718	1,206	16.67	3.224	5,381		"	(2,3,5,6)
BIL-GL-6-17	"	1.004	0.0722	987	13.63	3.189	4,258		"	(2,3,5,6)
BIL-GL-6-19	"	1.005	0.0723	1,064	14.65	3.332	4,448	0.098	"	(2,3,4,6)
BIL-GL-6-21	"	1.007	0.0704	1,094	15.44	3.278	4,678		"	(2,3,5,6)
			Average		15.42	3.273	4,795	0.092		
			Std. Dev.		1.33	0.067	484	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	115.4	23.05	5,210
	115.0	22.23	5,381
	94.0	21.99	4,258
	101.0	22.97	4,448
	106.4	22.60	4,678
Average	106.4	22.57	4,795
Std. Dev.	9.2	0.46	484

TABLE D.6

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Warp

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #2 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-18	72°F (WET)	0.999	0.0676	1,211	17.94	3.519	5,313		9/6/89	(2,3,5,6)
BIL-GL-3-20	"	1.003	0.0677	1,243	18.30	3.404	5,591	0.094	9/5/89	(2,3,4,6)
BIL-GL-4-17	"	1.002	0.0659	1,075	16.27	3.458	4,746		9/6/89	(2,3,5,6)
BIL-GL-4-19	"	0.998	0.0672	1,197	17.84	3.448	5,381		"	(2,3,5,6)
BIL-GL-4-21	"	1.002	0.0699	1,142	16.31	3.355	5,034	0.089	"	(2,3,4,6)
			Average		17.33	3.437	5,213	0.092		
			Std. Dev.		0.97	0.061	328	0.003		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	123.7	24.27	5,313
	126.2	23.47	5,591
	112.2	23.84	4,746
	123.0	23.77	5,381
	112.4	23.14	5,034
Average	119.5	23.70	5,213
Std. Dev.	6.7	0.42	328

TABLE D.7

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #1	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-1	-65°F (DRY)	1.000	0.0669	4,875	72.88	4.298	18,429+	0.153	5/10/89	(1,2,3,4,6,7)
BIL-GL-1(R)-7	"	1.002	0.0678	5,214	76.76	4.206	25,575		5/11/89	(1,2,3,5,6)
BIL-GL-1(R)-13	"	1.003	0.0677	5,100	75.08	4.206	24,330		"	(1,2,3,5,6)
BIL-GL-2(R)-5	"	1.001	0.0667	5,093	76.26	4.278	21,000+		5/10/89	(1,2,3,5,6,7)
BIL-GL-2(R)-11	"	1.005	0.0677	5,495	80.77	4.226	26,229	0.153	"	(1,2,3,4,6)
			Average		76.35	4.243	23,113+	0.153		
			Std. Dev.		2.89	0.043	3,304+	0.000		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimen soaked for 20 min. at test temperature.
(7) Strain gage failure due to outer ply separation.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
502.5	29.63	18,429+
529.3	29.00	25,575
517.7	29.00	24,330
525.8	29.50	21,000+
556.9	29.14	26,229
526.4	29.26	23,113+
19.9	0.29	3,304+

TABLE D.8

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-1	-65°F (DRY)	1.000	0.0662	4,410	66.63	4.646	20,507	0.180	5/9/89	(1,2,3,4)
BIL-GL-5-7	"	1.000	0.0699	4,286	61.31	4.036	12,000+		5/10/89	(1,2,3,5,6)
BIL-GL-5-13	"	1.003	0.0699	4,150	59.20	3.974	19,500+		"	(1,2,3,5,6)
BIL-GL-6-5	"	1.003	0.0680	5,140	75.38	4.180	24,429	0.145	"	(1,2,3,4)
BIL-GL-6-11	"	1.002	0.0691	5,760	83.20	4.189	14,357+	0.139	5/9/89	(1,3,4,6)
			Average		69.15	4.205	18,159+	0.155		
			Std. Dev.		10.04	0.263	4,975+	0.022		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Strain gage failure due to outer ply separation.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	459.4	32.03	20,507
	422.7	27.83	12,000+
	408.2	27.40	19,500+
	519.8	28.82	24,429
	573.7	28.88	14,357+
Average	476.8	28.99	18,159+
Std. Dev.	69.2	1.81	4,975+

TABLE D.9

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-1	-65°F (DRY)	1.007	0.0683	4,835	70.31	3.999	23,036	0.164	5/10/89	(1,2,3,4)
BIL-GL-3-7	〃	1.004	0.0703	4,857	68.83	4.049	21,300+		〃	(1,2,3,5,6)
BIL-GL-3-13	〃	0.998	0.0688	4,914	71.56	4.056	24,120		〃	(1,2,3,5)
BIL-GL-4-5	〃	0.998	0.0674	4,693	69.74	4.299	9,000+		〃	(1,2,3,5,6)
BIL-GL-4-11	〃	1.001	0.0690	4,915	71.17	4.163	24,643+	0.146	〃	(1,2,3,4,6)
			Average		70.32	4.113	20,419+	0.155		
			Std. Dev.		1.10	0.120	6,511+	0.013		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Strain gage failure due to outer ply separation.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	484.8	27.57	23,036
	474.6	27.92	21,300+
	493.4	27.97	24,120
	480.8	29.64	9,000+
	490.7	28.70	24,643+
Average	484.9	28.36	20,419+
Std. Dev.	7.6	0.83	6,511+

TABLE D.10

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B 7781 Glass				Batch #1	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-2	72°F (DRY)	1.002	0.0675	3,893	57.54	3.748	18,420	0.129	4/18/89	(2,3,4)
BIL-GL-1(R)-8	"	0.986	0.0669	3,864	58.58	4.115	18,705		"	(2,3,5)
BIL-GL-1(R)-14	"	1.002	0.0678	3,296	48.53	3.812	15,420		4/25/89	(2,3,5)
BIL-GL-2(R)-6	"	0.971	0.0674	3,493	53.37	4.147	16,920		4/20/89	(2,3,5)
BIL-GL-2(R)-12	"	1.002	0.0687	3,350	48.66	3.787	15,795	0.118	"	(2,3,4)
			Average		53.34	3.922	17,052	0.124		
			Std. Dev.		4.75	0.193	1,489	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
396.7	25.84	18,420
403.9	28.37	18,705
334.6	26.28	15,420
368.0	28.60	16,920
335.5	26.11	15,795
Average	367.7	27.04	17,052
Std. Dev.	32.7	1.33	1,489

TABLE D.11

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-2	72°F (DRY)	0.997	0.0686	3,375	49.33	3.628	16,570	0.143	5/11/89	(1,2,3,4)
BIL-GL-5-8	"	1.000	0.0671	3,607	53.75	3.592	18,450		"	(2,3,5)
BIL-GL-5-14	"	1.001	0.0672	3,589	53.36	3.531	18,150		"	(1,2,3,5)
BIL-GL-6-6	"	1.002	0.0672	3,729	55.36	3.579	18,830		"	(1,2,3,5)
BIL-GL-6-12	"	1.002	0.0701	3,875	55.16	3.381	20,250	0.113	"	(1,2,3,4)
			Average		53.39	3.542	18,450	0.128		
			Std. Dev.		2.43	0.097	1,324	0.021		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	340.1	25.02	16,570
	370.6	24.77	18,450
	367.9	24.35	18,150
	381.7	24.68	18,830
	380.3	23.31	20,250
Average	368.2	24.42	18,450
Std. Dev.	16.8	0.67	1,324

TABLE D.12

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-2	72°F (DRY)	0.997	0.0692	3,729	54.02	3.493	25,950+	0.131	5/11/89	(1,3,4,9)
BIL-GL-3-8	"	1.001	0.0702	3,957	56.33	3.482	19,950		"	(1,3,5)
BIL-GL-3-14	"	1.004	0.0677	3,686	54.21	3.520	18,585		"	(1,3,5)
BIL-GL-4-6	"	0.999	0.0658	3,882	59.03	3.726	19,650		"	(1,2,3,5)
BIL-GL-4-12	"	1.001	0.0687	3,904	56.78	3.506	19,695	0.129	"	(1,2,3,4)
			Average		56.08	3.545	20,766+	0.130		
			Std. Dev.		2.06	0.102	2,945+	0.002		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Strain gage failure due to outer ply separation.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
372.5	24.08	25,950+
388.4	24.01	19,950
373.8	24.27	18,585
407.0	25.69	19,650
391.5	24.18	19,695
Average	386.6	24.45	20,766+
Std. Dev.	14.2	0.70	2,945+

TABLE D.13

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #1	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-3	200°F (DRY)	1.001	0.0680	3,150	46.29	3.527	14,979	0.111	5/11/89	(2,3,4)
BIL-GL-1(R)-9	〃	0.998	0.0671	3,018	45.08	3.575	14,445		5/12/89	(1,2,3,5)
BIL-GL-1(R)-15	〃	0.999	0.0695	3,289	47.36	3.548	15,450		5/11/89	(2,3,5)
BIL-GL-2(R)-7	〃	1.003	0.0692	3,507	50.54	3.680	16,500		〃	(1,3,5)
BIL-GL-2(R)-13	〃	0.999	0.0691	3,000	43.45	3.404	14,614	0.121	〃	(1,3,4)
			Average		46.55	3.547	15,198	0.116		
			Std. Dev.		2.66	0.099	824	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
319.2	24.32	14,979
310.9	24.65	14,445
326.6	24.46	15,450
348.5	25.37	16,500
299.6	23.47	14,614
Average	320.9	24.45	15,198
Std. Dev.	18.4	0.68	824

TABLE D.14

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; 7781 Glass — Batch #2 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-3	200°F (DRY)	1.002	0.0709	3,025	42.60	3.380	14,700	0.096	5/12/89	(2,3,4)
BIL-GL-5-9	"	0.998	0.0673	2,996	44.63	3.537	14,565		5/11/89	(1,3,5)
BIL-GL-5-15	"	1.001	0.0663	3,029	45.64	3.579	14,325		5/12/89	(1,2,3,5)
BIL-GL-6-7	"	1.001	0.0669	3,186	47.56	3.626	15,180		5/11/89	(1,2,3,5)
BIL-GL-6-13	"	0.999	0.0692	3,178	45.95	3.453	15,707	0.093	5/12/89	(1,3,4)
			Average		45.28	3.515	14,895	0.095		
			Std. Dev.		1.83	0.099	551	0.003		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	293.7	23.30	14,700
	307.7	24.39	14,565
	314.7	24.68	14,325
	327.9	25.00	15,180
	316.8	23.81	15,707
Average	312.2	24.24	14,895
Std. Dev.	12.6	0.68	551

TABLE D.15

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-3	200°F (DRY)	1.004	0.0699	2,600	37.04	3.579	13,500	0.100	5/12/89	(2,3,4)
BIL-GL-3-9	"	1.001	0.0686	3,161	46.05	3.434	9,750		5/8/89	(1,3,5)
BIL-GL-3-15	"	1.004	0.0689	2,968	42.89	3.587	13,980		5/11/89	(1,2,3,5)
BIL-GL-4-7	"	1.000	0.0674	3,246	48.16	3.629	15,795		"	(1,2,3,5)
BIL-GL-4-13	"	1.004	0.0694	3,120	44.80	3.356	12,000+	0.087	5/12/89	(1,2,3,4,6)
			Average		43.79	3.517	13,005+	0.094		
			Std. Dev.		4.23	0.116	2,268+	0.009		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Strain gage failure due to outer ply separation.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	255.4	24.68	13,500
	317.5	23.68	9,750
	295.7	24.73	13,980
	332.0	25.02	15,795
	308.9	23.14	12,000+
Average	301.9	24.25	13,005+
Std. Dev.	29.2	0.80	2,268+

TABLE D.16

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; 7781 Glass — Batch #1 — Task #3 — Tested by : DRB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-4	-65°F (WET)	1.002	0.0682	1,238	18.11	3.890	5,024		9/13/89	(2,3,5,6)
BIL-GL-1(R)-10	〃	0.996	0.0684	1,421	20.86	3.986	6,006	0.154	9/12/89	(2,3,4,6)
BIL-GL-2(R)-1	〃	1.002	0.0656	1,490	22.67	3.875	6,597		9/13/89	(2,3,5,6)
BIL-GL-2(R)-8	〃	1.005	0.0699	1,439	20.50	3.767	6,118		〃	(2,3,5,6)
BIL-GL-2(R)-14	〃	0.999	0.0677	1,048	15.49	3.880	4,000	0.133	9/12/89	(2,3,4,6)
			Average		19.53	3.880	5,549	0.143		
			Std. Dev.		2.78	0.078	1,037	0.015		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	124.9	26.82	5,024
	143.8	27.48	6,006
	156.3	26.72	6,597
	141.4	25.97	6,118
	106.8	26.75	4,000
Average	134.6	26.75	5,549
Std. Dev.	19.2	0.53	1,037

TABLE D.17

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) WET

Test :	Straight sided tension; ASTM-D3039							Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #3			Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-4	-65°F (WET)	1.002	0.0682	1,545	22.61	3.699	6,943		9/13/89	(1,3,5,6)
BIL-GL-5-10	"	1.003	0.0676	1,477	21.79	3.752	6,567	0.120	9/12/89	(2,3,4,6)
BIL-GL-6-1	"	0.996	0.0631	1,586	25.24	4.027	7,168		9/13/89	(2,3,5,6)
BIL-GL-6-8	"	1.000	0.0689	1,680	24.39	3.870	7,295		"	(2,3,5,6)
BIL-GL-6-14	"	0.995	0.0699	1,362	19.57	3.473	6,172	0.113	9/12/89	(2,3,4,6)
			Average		22.72	3.764	6,829	0.117		
			Std. Dev.		2.23	0.206	460	0.005		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
155.9	25.51	6,943
150.2	25.87	6,567
174.0	27.77	7,168
168.2	26.68	7,295
135.0	23.94	6,172
Average	156.7	25.95	6,829
Std. Dev.	15.4	1.42	460

TABLE D.18

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #3	Task #3			Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-4	-65°F (WET)	1.003	0.0709	1,331	18.72	3.740	5,435		9/13/89	(2,3,5,6)
BIL-GL-3-10	"	1.005	0.0672	1,430	21.17	3.873	6,138	0.144	9/12/89	(2,3,4,6)
BIL-GL-4-1	"	1.000	0.0662	1,582	23.89	3.785	7,109		9/13/89	(2,3,5,6)
BIL-GL-4-8	"	0.999	0.0671	1,549	23.11	3.843	6,846		"	(2,3,5,6)
BIL-GL-4-14	"	1.006	0.0701	1,416	20.07	3.632	6,216	0.145	9/12/89	(2,3,4,6)
			Average		21.39	3.775	6,349	0.145		
			Std. Dev.		2.13	0.095	656	0.001		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

	SI Conversion		
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	129.1	25.79	5,435
	145.9	26.71	6,138
	164.7	26.09	7,109
	159.3	26.50	6,846
	138.4	25.04	6,216
Average	147.5	26.03	6,349
Std. Dev.	14.7	0.65	656

TABLE D.19

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #1	Task #3			Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-5	72°F (WET)	1.003	0.0674	1,219	18.03	3.362	5,591		9/8/89	(2,3,5,6)
BIL-GL-1(R)-11	"	1.000	0.0688	1,298	18.86	3.236	6,206	0.097	"	(2,3,4,6)
BIL-GL-2(R)-2	"	0.997	0.0672	1,364	20.36	3.316	6,460		"	(2,3,5,6)
BIL-GL-2(R)-9	"	0.999	0.0682	1,290	18.93	3.270	6,099		"	(2,3,5,6)
BIL-GL-2(R)-15	"	1.003	0.0691	1,218	17.58	3.126	5,957	0.097	"	(2,3,4,6)
			Average		18.75	3.262	6,063	0.097		
			Std. Dev.		1.06	0.090	322	0.000		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
124.3	23.18	5,591
130.0	22.31	6,206
140.4	22.86	6,460
130.5	22.55	6,099
121.2	21.55	5,957
Average	129.3	22.49	6,063
Std. Dev.	7.3	0.62	322

TABLE D.20

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #3			Tested by :	TOB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-5	72°F (WET)	1.004	0.0683	1,077	15.70	3.090	5,273		9/7/89	(2,3,5,6)
BIL-GL-5-11	"	1.001	0.0676	1,142	16.87	5.200	3,135	0.016	"	(2,3,4,6,7)
BIL-GL-6-2	"	1.001	0.0664	1,090	16.40	3.316	5,076		"	(2,3,5,6)
BIL-GL-6-9	"	1.000	0.0691	1,181	17.09	3.198	5,527		"	(2,3,5,6)
BIL-GL-6-15	"	1.001	0.0682	1,072	15.70	5.023	3,040	0.016	"	(2,3,4,6,7)
			Average		16.35	3.201	5,292	0.016		
			Std. Dev.		0.64	0.113	226	0.000		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.
(7) Probable improper strain range set. Not included in modulus, strain or Poisson's ratio averages.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
108.2	21.30	5,273
116.3	35.85	3,135
113.1	22.86	5,076
117.8	22.05	5,527
108.3	34.63	3,040
Average	112.7	22.07	5,292
Std. Dev.	4.4	0.78	226

TABLE D.21

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #3				Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-5	72°F (WET)	1.005	0.0706	1,168	16.46	3.167	5,430		9/11/89	(1,3,5,6)
BIL-GL-3-11	"	1.004	0.0674	1,348	19.93	3.218	6,514	0.079	"	(1,3,4,6)
BIL-GL-4-2	"	1.000	0.0676	1,219	18.03	3.207	5,957		"	(2,3,5,6)
BIL-GL-4-9	"	1.002	0.0674	1,173	17.37	3.219	5,664		"	(2,3,5,6)
BIL-GL-4-15	"	0.999	0.0685	1,085	15.86	3.148	5,303	0.093	"	(2,3,4,6)
			Average		17.53	3.192	5,773	0.086		
			Std. Dev.		1.58	0.033	483	0.010		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
113.5	21.84	5,430
137.4	22.19	6,514
124.3	22.12	5,957
119.8	22.20	5,664
109.4	21.70	5,303
120.9	22.01	5,773
10.9	0.22	483

TABLE D.22

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; 7781 Glass — Batch #1 — Task #3 — Tested by : DRB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-6	200°F (WET)	0.994	0.0672	948	14.19	2.944	4,751		9/14/89	(2,3,4,6)
BIL-GL-1(R)-12	"	0.997	0.0677	934	13.85	2.910	4,697	0.081	"	(2,3,5,6)
BIL-GL-2(R)-3	"	1.000	0.0672	910	13.53	2.865	4,644		"	(2,3,5,6)
BIL-GL-2(R)-10	"	0.995	0.0672	848	12.67	2.825	4,370		"	(2,3,5,6)
BIL-GL-2(R)-16	"	1.004	0.0672	933	13.83	2.816	4,663	0.016	"	(1,3,4,6)
			Average		13.61	2.872	4,625	0.048		
			Std. Dev.		0.58	0.055	148	0.046		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	97.9	20.30	4,751
	95.5	20.07	4,697
	93.3	19.76	4,644
	87.4	19.48	4,370
	95.3	19.41	4,663
Average	93.9	19.80	4,625
Std. Dev.	4.0	0.38	148

TABLE D.23

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; 7781 Glass				Batch #2	Task #3			Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-6	200°F (WET)	1.003	0.0681	903	13.21	3.497	4,873	0.126	9/14/89	(2,3,4,6)
BIL-GL-5-12	"	1.005	0.0699	895	12.75	2.592	4,658	0.076	"	(2,3,4,6)
BIL-GL-6-3	"	1.001	0.0699	908	12.98	3.671	3,364		9/15/89	(2,3,5,6)
BIL-GL-6-10	"	1.003	0.0687	881	12.78	3.253	3,711		"	(2,3,5,6)
BIL-GL-6-16	"	0.994	0.0660	1,041	15.86	3.172	4,883		9/14/89	(1,3,5,6)
			Average		13.52	3.237	4,298	0.101		
			Std. Dev.		1.32	0.411	710	0.035		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
91.1	24.11	4,873
87.9	17.87	4,658
89.5	25.31	3,364
88.1	22.43	3,711
109.3	21.87	4,883
Average 93.2	22.32	4,298
Std. Dev. 9.1	2.84	710

TABLE D.24

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #3 — Tested by : DRB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-6	200°F (WET)	1.005	0.0699	955	13.59	2.863	4,468		9/15/89	(2,3,5,6)
BIL-GL-3-12	"	1.006	0.0688	930	13.45	2.642	4,902	0.086	9/14/89	(2,3,4,6)
BIL-GL-4-3	"	1.000	0.0685	1,013	14.79	2.919	4,712		9/15/89	(2,3,5,6)
BIL-GL-4-10	"	1.002	0.0680	940	13.79	3.551	3,774		"	(2,3,5,6)
BIL-GL-4-16	"	1.004	0.0689	822	11.89	2.583	4,575	0.088	9/14/89	(2,3,4,6)
			Average		13.50	2.912	4,486	0.087		
			Std. Dev.		1.04	0.385	430	0.002		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	93.7	19.74	4,468
	92.7	18.22	4,902
	102.0	20.13	4,712
	95.1	24.48	3,774
	82.0	17.81	4,575
Average	93.1	20.08	4,486
Std. Dev.	7.2	2.65	430

TABLE D.25

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #2				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-17	72°F (DRY)	1.002	0.1247	10,740	85.95	8.283	9,320		4/4/89	(2,3,4)
BIL-GR-7-19	"	1.004	0.1246	10,600	84.73	7.914	9,480		"	(2,3,4)
BIL-GR-7-21	"	1.004	0.1222	10,420	84.93	8.191	8,280		"	(2,3,4)
BIL-GR-8-18	"	1.003	0.1224	9,143	74.44	8.643	8,325	0.059	4/17/89	(2,3,5)
BIL-GR-8-20	"	1.002	0.1214	9,907	81.44	8.866	9,150	0.048	"	(2,3,5)
			Average		82.30	8.380	8,911	0.053		
			Std. Dev.		4.71	0.377	568	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" gage length axial extensometer attached.
(5) Specimen had 0° and 90° strain gages attached.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
592.7	57.11	9,320
584.2	54.57	9,480
585.6	56.48	8,280
513.3	59.59	8,325
561.6	61.13	9,150
Average 567.5	57.78	8,911
Std. Dev. 32.5	2.60	568

TABLE D.26

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039						Fiber Orientation :	Warp		
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #2		Tested by :	PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-17	72°F (DRY)	1.003	0.1290	9,775	75.53	7.689	7,950	0.065	4/3/89	(2,3,5)
BIL-GR-11-19	"	0.999	0.1234	9,750	79.07	8.272	8,700		"	(2,3,4)
BIL-GR-11-21	"	1.002	0.1200	10,340	85.97	8.647	7,200	0.040	"	(2,3,5)
BIL-GR-12-18	"	1.000	0.1252	10,650	85.06	8.227	7,150	0.053	"	(2,3,5)
BIL-GR-12-20	"	1.003	0.1264	10,300	81.24	8.084	6,535		"	(2,3,4)
			Average		81.37	8.184	7,507	0.053		
			Std. Dev.		4.31	0.346	835	0.013		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" gage length axial extensometer attached.
(5) 2.00" gage length biaxial extensometer attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	520.8	53.01	7,950
	545.2	57.03	8,700
	592.8	59.62	7,200
	586.5	56.72	7,150
	560.1	55.74	6,535
Average	561.1	56.43	7,507
Std. Dev.	29.7	2.39	835

TABLE D.27

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Warp

Material : EA-9396 A/B; W133 Graphite — Batch #3 — Task #2 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-17	72°F (DRY)	0.995	0.1251	9,150	73.54	8.519	7,400	0.075	4/4/89	(2,3,5)
BIL-GR-9-19	"	1.002	0.1245	10,630	85.18	9.215	5,500		"	(2,3,4)
BIL-GR-9-21	"	0.997	0.1263	9,200	73.08	8.619	6,900	0.071	"	(2,3,5)
BIL-GR-10-18	"	1.006	0.1272	9,475	74.07	8.131	7,200		"	(2,3,4)
BIL-GR-10-20	"	0.995	0.1238	10,500	85.28	8.325	8,300		"	(2,3,4)
			Average		78.23	8.562	7,060	0.073		
			Std. Dev.		6.40	0.410	1,016	0.003		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" gage length axial extensometer attached.
(5) 2.00" gage length biaxial extensometer attached.

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
507.0	58.74	7,400
587.3	63.54	5,500
503.9	59.43	6,900
510.7	56.06	7,200
588.0	57.40	8,300
Average	539.4	59.03	7,060
Std. Dev.	44.1	2.83	1,016

TABLE D.28

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #2				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-18	72°F (WET)	1.004	0.1243	9,971	79.94	9.088	8,804		9/13/89	(2,3,5,6,7)
BIL-GR-7-20	"	1.004	0.1227	11,172	90.69	9.128	10,144	0.018	"	(1,3,4,6,7)
BIL-GR-8-17	"	1.005	0.1219	11,099	90.63	8.885	10,049		"	(1,3,5,6)
BIL-GR-8-19	"	1.001	0.1246	10,059	80.67	8.807	9,148		"	(1,2,3,5,6)
BIL-GR-8-21	"	0.998	0.1171	10,689	91.43	9.342	9,946	0.040	"	(1,3,4,6)
			Average		86.67	9.050	9,618	0.029		
			Std. Dev.		5.83	0.212	603	0.015		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.
(7) Tabs debonded; specimen did not fail.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
551.2	62.66	8,804
625.3	62.93	10,144
624.9	61.26	10,049
556.2	60.72	9,148
630.4	64.41	9,946
Average	597.6	62.40	9,618
Std. Dev.	40.2	1.46	603

TABLE D.29

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; W133 Graphite				Batch #2	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-18	72°F (WET)	1.002	0.1286	9,575	74.28	8.280	8,796		9/12/89	(1,3,5,6)
BIL-GR-11-20	"	0.999	0.1233	10,264	83.34	8.765	9,294	0.034	"	(1,3,4,6)
BIL-GR-12-17	"	1.004	0.1279	11,045	85.98	8.773	9,595		"	(1,2,3,5,6)
BIL-GR-12-19	"	1.000	0.1254	10,718	85.43	8.536	9,873		"	(1,3,5,6)
BIL-GR-12-21	"	1.002	0.1230	9,712	78.79	8.856	8,826	0.049	"	(1,3,4,6)
			Average		81.56	8.642	9,277	0.041		
			Std. Dev.		4.96	0.235	472	0.011		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
512.2	57.09	8,796
574.6	60.43	9,294
592.8	60.49	9,595
589.1	58.85	9,873
543.2	61.06	8,826
Average 562.4	59.59	9,277
Std. Dev. 34.2	1.62	472

TABLE D.30

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; W133 Graphite				Batch #3	Task #2			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-18	72°F (WET)	1.002	0.1244	11,257	90.36	8.854	10,410		9/12/89	(1,3,5,6)
BIL-GR-9-20	"	0.997	0.1249	10,200	81.95	8.649	9,653	0.034	"	(1,2,3,4,6)
BIL-GR-10-17	"	1.002	0.1262	10,643	84.16	8.438	9,780		9/13/89	(2,3,5,6)
BIL-GR-10-19	"	1.000	0.1241	10,879	87.66	8.743	9,880		"	(1,2,3,5,6)
BIL-GR-10-21	"	1.001	0.1187	10,490	88.27	9.200	9,429	0.048	9/12/89	(2,3,4,6)
			Average		86.48	8.777	9,831	0.041		
			Std. Dev.		3.37	0.282	365	0.010		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
623.0	61.05	10,410
565.1	59.64	9,653
580.3	58.18	9,780
604.4	60.29	9,880
608.6	63.43	9,429
596.3	60.52	9,831
23.2	1.94	365

TABLE D.31

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite				Batch #1	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-1	-65°F (DRY)	1.0005	0.1113	11,196	100.55	9.153	10,576	0.053	6/13/89	(2,3,4)
BIL-GR-7-7	"	0.9971	0.1228	11,411	93.19	9.129	10,129		"	(1,2,3,5)
BIL-GR-7-13	"	0.9972	0.1208	11,118	92.30	9.085	10,283		"	(2,3,5)
BIL-GR-8-5	"	1.0000	0.1194	10,581	88.62	9.044	10,581	0.059	"	(2,3,4)
BIL-GR-8-11	"	1.0010	0.1189	10,864	91.28	9.125	9,624	0.068	"	(1,2,3,4)
			Average		93.19	9.107	10,239	0.060		
			Std. Dev.		4.46	0.043	395	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	693.3	63.11	10,576
	642.6	62.95	10,129
	636.4	62.64	10,283
	611.0	62.36	10,581
	629.4	62.92	9,624
Average	642.5	62.80	10,239
Std. Dev.	30.7	0.30	395

TABLE D.32

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-1	-65°F (DRY)	0.997	0.1098	11,699	106.88	10.202	10,195		6/13/89	(1,2,3,5)
BIL-GR-11-7	"	0.996	0.1229	10,147	82.89	8.333	9,031		"	(2,3,5)
BIL-GR-11-13	"	1.001	0.1180	10,205	86.38	9.159	8,958	0.050	"	(1,3,4)
BIL-GR-12-5	"	1.003	0.1159	9,912	85.28	9.083	8,936		"	(2,3,5)
BIL-GR-12-11	"	1.001	0.1180	10,361	87.73	9.369	9,294	0.045	"	(2,3,4)
			Average		89.83	9.229	9,283	0.048		
			Std. Dev.		9.69	0.670	530	0.003		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	736.9	70.34	10,195
	571.5	57.45	9,031
	595.6	63.15	8,958
	588.0	62.63	8,936
	604.9	64.60	9,294
Average	619.4	63.63	9,283
Std. Dev.	66.8	4.62	530

TABLE D.33

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; W133 Graphite — Batch #3 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-1	-65°F (DRY)	0.998	0.1096	10,034	91.71	10.005	8,914		6/14/89	(1,3,5)
BIL-GR-9-7	"	0.995	0.1192	10,137	85.46	9.251	9,900		"	(2,3,5)
BIL-GR-9-13	"	0.988	0.1199	10,566	89.20	9.540	8,848	0.049	6/13/89	(2,3,4)
BIL-GR-10-5	"	0.999	0.1189	10,205	85.88	9.472	9,053		6/14/89	(2,3,5)
BIL-GR-10-11	"	0.996	0.1172	10,640	91.16	9.434	9,324	0.056	6/13/89	(1,2,3,4)
			Average		88.68	9.540	9,208	0.053		
			Std. Dev.		2.91	0.281	428	0.005		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	632.3	68.98	8,914
	589.2	63.78	9,900
	615.0	65.78	8,848
	592.1	65.31	9,053
	628.5	65.04	9,324
Average	611.4	65.78	9,208
Std. Dev.	20.0	1.94	428

TABLE D.34

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; W133 Graphite — Batch #1 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-2	72°F (DRY)	1.004	0.1166	11,600	99.12	8.630	11,600	0.048	5/3/89	(1,2,3,4)
BIL-GR-7-8	〃	1.002	0.1275	12,243	95.88	7.943	11,100		〃	(1,2,3,5)
BIL-GR-7-14	〃	0.999	0.1250	11,520	92.25	8.408	10,542	0.048	〃	(2,3,4)
BIL-GR-8-6	〃	1.003	0.1242	12,586	101.02	8.170	11,700		〃	(1,3,5)
BIL-GR-8-12	〃	1.004	0.1233	11,530	93.15	8.240	10,843	0.046	〃	(2,3,4)
			Average		96.28	8.278	11,157	0.048		
			Std. Dev.		3.77	0.258	493	0.001		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	683.4	59.50	11,600
	661.1	54.77	11,100
	636.1	57.98	10,542
	696.5	56.33	11,700
	642.3	56.82	10,843
Average	663.9	57.08	11,157
Std. Dev.	26.0	1.78	493

TABLE D.35

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-2	72°F(DRY)	0.9997	0.1192	12,065	101.25	8.870	11,616	0.053	6/13/89	(1,2,3,4)
BIL-GR-11-8	"	0.4982	0.1260	5,175	82.44	7.308	9,493	0.039	4/26/89	(1,3,4,6)
BIL-GR-11-14	"	1.0029	0.1231	12,056	97.65	8.563	10,920	0.068	6/13/89	(1,2,3,4)
BIL-GR-12-6	"	0.4981	0.1228	4,880	79.78	7.868	9,632	0.044	4/26/89	(1,3,4,6)
BIL-GR-12-12	"	1.0039	0.1227	12,329	100.09	8.936	11,148	0.068	6/13/89	(1,3,4)
			Average		99.66	8.790	11,228	0.063		
			Std. Dev.		1.84	0.199	355	0.009		

Remarks:

(1) Specimen failed within the gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" biaxial gage length extensometer.
(5) Specimen had 0° and 90° strain gages attached.
(6) Specimen tested in dogbone shape, not included in averages.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	698.1	61.16	11,616
	568.4	50.39	9,493
	673.3	59.04	10,920
	550.1	54.25	9,632
	690.1	61.61	11,148
Average	687.2	60.60	11,228
Std. Dev.	12.7	1.37	355

TABLE D.36

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) DRY

Test :	Straight sided tension; ASTM-D3039									Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite				Batch #3	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks	
BIL-GR-9-2	72°F (DRY)	0.994	0.1149	10,200	89.32	9.445	9,180		4/20/89	(2,3,5)	
BIL-GR-9-8	"	1.004	0.1237	12,500	100.70	8.890	11,085		4/24/89	(1,3,5)	
BIL-GR-9-14	"	1.001	0.1216	11,457	94.13	8.978	8,940	0.044	"	(2,3,4)	
BIL-GR-10-6	"	1.000	0.1216	9,129	75.07	8.635	8,520		4/20/89	(2,3,5)	
			Average		89.80	8.987	9,431				
			Std. Dev.		10.87	0.338	1,136				

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) 2.00" gage length biaxial extensometer attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	615.8	65.12	9,180
	694.3	61.30	11,085
	649.0	61.91	8,940
	517.6	59.54	8,520
Average	619.2	61.97	9,431
Std. Dev.	75.0	2.33	1,136

TABLE D.37

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #1		Task #3			Tested by :	DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-3	200°F (DRY)	0.999	0.1183	6,768	57.30	8.830	6,460		6/15/89	(2,3,5,6)
BIL-GR-7-9	"	1.002	0.1187	8,499	71.45	8.235	8,467		1/9/90	(2,3,5,6)
BIL-GR-7-15	"	0.999	0.1189	8,132	68.46	8.387	7,998	0.051	1/10/90	(2,3,4,6)
BIL-GR-8-7	"	0.998	0.1194	8,108	68.05	8.305	8,066		1/9/90	(2,3,5,6)
BIL-GR-8-13	"	1.000	0.1256	8,147	64.87	7.746	8,145	0.022	1/10/90	(2,3,4,6)
			Average		66.03	8.301	7,827	0.037		
			Std. Dev.		5.41	0.387	785	0.020		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Tabs debonded; specimen tested without tabs.

SI Conversion				
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)	
	395.1	60.88	6,460	
	492.7	56.78	8,467	
	472.1	57.83	7,998	
	469.2	57.27	8,066	
	447.3	53.41	8,145	
Average	455.3	57.23	7,827	
Std. Dev.	37.3	2.67	785	

TABLE D.38

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) DRY

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; W133 Graphite — Batch #2 — Task #3 — Tested by : DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-3	200°F (DRY)	1.001	0.1172	10,757	91.70	9.226	9,712		6/15/89	(1,2,3,5)
BIL-GR-11-9	"	0.998	0.1198	8,416	70.37	8.491	8,110		1/9/90	(2,3,5,6)
BIL-GR-11-15	"	1.000	0.1139	9,229	81.06	8.776	9,087	0.046	"	(2,3,4)
BIL-GR-12-7	"	0.996	0.1172	7,686	65.83	8.366	7,749		"	(2,3,5,6)
BIL-GR-12-13	"	1.000	0.1170	9,583	81.89	8.119	10,039	0.060	"	(1,3,4)
			Average		78.17	8.596	8,940	0.053		
			Std. Dev.		10.23	0.424	992	0.010		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Tabs debonded; specimen tested without tabs.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	632.3	63.61	9,712
	485.2	58.55	8,110
	558.9	60.51	9,087
	453.9	57.68	7,749
	564.6	55.98	10,039
Average	539.0	59.27	8,940
Std. Dev.	70.5	2.93	992

TABLE D.39

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) DRY

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-3	200°F (DRY)	0.9982	0.1192	10,271	86.33	9.155	9,195		5/8/89	(1,2,3,5)
BIL-GR-9-9	"	1.0013	0.1233	9,929	80.42	8.910	8,895		"	(1,3,5)
BIL-GR-9-16	"	1.0024	0.1195	9,810	81.90	9.183	8,850	0.063	5/9/89	(1,3,4)
BIL-GR-10-7	"	0.9971	0.1198	8,900	74.51	8.910	8,340		5/8/89	(2,3,5)
BIL-GR-10-13	"	1.0001	0.1151	10,140	88.09	9.035	9,686	0.102	5/9/89	(1,2,3,4)
			Average		82.25	9.038	8,993	0.082		
			Std. Dev.		5.34	0.130	494	0.028		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	595.2	63.12	9,195
	554.5	61.43	8,895
	564.7	63.32	8,850
	513.7	61.43	8,340
	607.4	62.29	9,686
Average	567.1	62.32	8,993
Std. Dev.	36.8	0.90	494

TABLE D.40

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) WET

Test :	Straight sided tension; ASTM-D3039						Fiber Orientation :		Fill	
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #3		Tested by :		PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-4	-65°F (WET)	0.997	0.1239	12,505	101.24	9.214	11,104	0.052	9/7/89	(1,2,3,4,6)
BIL-GR-7-10	"	0.999	0.1248	11,499	92.23	8.906	10,225		"	(2,3,5,6)
BIL-GR-8-1	"	0.998	0.1099	10,586	96.53	9.912	9,514		"	(2,3,5,6)
BIL-GR-8-8	"	1.001	0.1213	11,470	94.46	9.454	7,214		"	(1,2,3,5,6)
BIL-GR-8-14	"	1.003	0.1152	11,831	102.39	9.434	10,745	0.041	"	(1,2,3,4,6)
			Average		97.37	9.384	9,760	0.046		
			Std. Dev.		4.35	0.369	1,544	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
698.1	63.53	11,104
635.9	61.41	10,225
665.5	68.34	9,514
651.3	65.18	7,214
706.0	65.05	10,745
Average	671.4	64.70	9,760
Std. Dev.	30.0	2.54	1,544

TABLE D.41

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-4	-65°F (WET)	0.999	0.1197	10,996	91.93	9.485	9,368		9/8/89	(1,2,3,5,6)
BIL-GR-11-10	"	0.999	0.1206	12,148	100.82	9.382	10,378	0.051	9/7/89	(1,2,3,4,6)
BIL-GR-12-1	"	0.999	0.1119	9,009	80.60	9.655	8,005		9/8/89	(1,3,5,6)
BIL-GR-12-8	"	0.998	0.1181	11,895	100.93	9.347	10,408		"	(1,2,3,5,6)
BIL-GR-12-14	"	0.999	0.1177	11,480	97.61	9.680	10,151	0.041	9/7/89	(1,2,3,4,6)
			Average		94.38	9.510	9,662	0.046		
			Std. Dev.		8.53	0.153	1,017	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	633.8	65.40	9,368
	695.2	64.69	10,378
	555.7	66.57	8,005
	695.9	64.44	10,408
	673.0	66.74	10,151
Average	650.7	65.57	9,662
Std. Dev.	58.8	1.05	1,017

TABLE D.42

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite				Batch #3	Task #3			Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-4	-65°F (WET)	0.995	0.1178	11,670	99.59	9.620	10,217	0.050	9/8/89	(1,2,3,4,6)
BIL-GR-9-10	"	0.996	0.1213	10,527	87.12	9.164	9,353		"	(1,2,3,5,6)
BIL-GR-10-1	"	0.998	0.1078	11,284	104.89	10.359	9,976		"	(1,2,3,5,6)
BIL-GR-10-8	"	0.996	0.1181	11,221	95.40	9.301	10,129		"	(1,2,3,5,6)
BIL-GR-10-14	"	0.999	0.1149	11,948	104.09	9.852	10,613	0.086	"	(1,2,3,4,6)
			Average		98.22	9.659	10,058	0.068		
			Std. Dev.		7.28	0.475	459	0.025		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
686.7	66.33	10,217
600.7	63.18	9,353
723.2	71.43	9,976
657.8	64.13	10,129
717.7	67.93	10,613
677.2	66.60	10,058
50.2	3.28	459

Average
Std. Dev.

TABLE D.43

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; W133 Graphite — Batch #1 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-5	72°F (WET)	1.002	0.1267	9,146	72.02	8.552	8,386		9/6/89	(2,3,5,6)
BIL-GR-7-11	"	0.999	0.1260	10,327	82.08	8.845	9,338	0.035	"	(2,3,4,6)
BIL-GR-8-2	"	1.003	0.1152	11,533	99.84	8.958	10,994		"	(1,3,5,6)
BIL-GR-8-4	"	1.005	0.1244	10,508	84.05	8.407	9,829		"	(1,3,5,6)
BIL-GR-8-9	"	1.003	0.1266	9,771	76.96	8.373	9,082	0.038	"	(2,3,4,6)
			Average		82.99	8.627	9,526	0.037		
			Std. Dev.		10.52	0.262	972	0.002		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	496.6	58.97	8,386
	566.0	60.98	9,338
	688.4	61.76	10,994
	579.5	57.97	9,829
	530.6	57.73	9,082
Average	572.2	59.48	9,526
Std. Dev.	72.5	1.81	972

TABLE D.44

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) WET

Test : Straight sided tension; ASTM-D3039 — Fiber Orientation : Fill

Material : EA-9396 A/B; W133 Graphite — Batch #2 — Task #3 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-5	72°F (WET)	1.003	0.1171	10,586	90.17	9.150	9,543		9/11/89	(1,2,3,5,6)
BIL-GR-11-11	"	1.000	0.1118	11,318	101.27	9.633	10,430	0.043	"	(1,2,3,4,6)
BIL-GR-12-2	"	1.001	0.1177	10,332	87.66	8.581	9,998		"	(1,2,3,5,6)
BIL-GR-12-9	"	1.004	0.1237	10,176	81.94	8.383	9,653		"	(1,3,5,6)
BIL-GR-12-15	"	1.005	0.1239	10,986	88.25	8.222	11,697	0.049	"	(1,3,4,6)
			Average		89.86	8.794	10,264	0.046		
			Std. Dev.		7.08	0.586	872	0.004		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	621.7	63.09	9,543
	698.2	66.42	10,430
	604.4	59.16	9,998
	565.0	57.80	9,653
	608.5	56.69	11,697
Average	619.6	60.63	10,264
Std. Dev.	48.8	4.04	872

TABLE D.45

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #3				Tested by :	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-5	72°F (WET)	1.003	0.1240	10,703	86.08	8.624	9,741		9/11/89	(1,2,3,5,6)
BIL-GR-9-11	"	1.002	0.1247	10,762	86.10	8.881	9,683	0.058	"	(1,2,3,4,6)
BIL-GR-10-2	"	1.002	0.1163	11,040	94.73	8.933	10,547		"	(1,2,3,5,6)
BIL-GR-10-9	"	1.002	0.1253	10,674	85.04	8.516	10,181		"	(1,3,5,6)
BIL-GR-10-15	"	1.002	0.1173	11,401	96.99	8.947	11,279	0.053	"	(1,3,4,6)
			Average		89.79	8.780	10,286	0.056		
			Std. Dev.		5.62	0.197	657	0.003		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	593.5	59.47	9,741
	593.7	61.24	9,683
	653.1	61.59	10,547
	586.4	58.72	10,181
	668.8	61.69	11,279
Average	619.1	60.54	10,286
Std. Dev.	38.7	1.36	657

TABLE D.46

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) WET

Test :	Straight sided tension; ASTM-D3039							Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #3			Tested by :	PM & DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-6	200°F (WET)	0.997	0.1244	7,993	64.47	7.612	7,727	0.034	1/23/90	(2,3,4,6,8)
BIL-GR-7-12	"	1.001	0.1229	7,666	62.31	7.801	7,427	0.015	9/13/89	(1,3,4,6)
BIL-GR-8-3	"	1.007	0.1141	8,096	70.46	9.197	3,071		9/15/89	(1,3,5,6,7)
BIL-GR-8-10	"	0.998	0.1205	6,624	56.72	7.492	7,749		1/23/90	(2,3,5,6,8)
BIL-GR-8-16	"	1.006	0.1138	8,140	71.10	7.679	9,316	0.052	"	(1,3,4,6,8)
			Average		65.01	7.956	7,058	0.034		
			Std. Dev.		5.98	0.703	2,348	0.018		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed at grip edge.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° Strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.
(7) Strain gage failed prematurely due to ply failure.
(8) Tested without tabs.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
444.5	52.49	7,727
429.7	53.79	7,427
485.8	63.41	3,071
391.1	51.65	7,749
490.2	52.94	9,316
448.3	54.86	7,058
41.2	4.84	2,348

TABLE D.47

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #3				Tested by :	PM & DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-6	200°F (WET)	0.994	0.1195	7,935	66.81	8.581	8,262	0.048	1/23/90	(3,4,6,7,8)
BIL-GR-11-12	"	0.998	0.1189	7,188	60.59	8.861	5,530	0.052	9/14/89	(3,4,6,8)
BIL-GR-12-3	"	0.998	0.1177	7,434	63.30	8.131	9,067		1/23/90	(1,2,3,5,6,7)
BIL-GR-12-4	"	1.001	0.1176	7,405	62.91	7.083	9,521	0.036	"	(3,4,6,7,8)
BIL-GR-12-10	"	0.999	0.1157	7,141	61.78	7.754	8,438	0.061	"	(3,4,6,7,8)
			Average		63.08	8.082	8,164	0.049		
			Std. Dev.		2.34	0.701	1,556	0.010		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95–100% R.H.
(7) Testd without tabs.
(8) Failed at grip edge.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
460.6	59.17	8,262
417.8	61.09	5,530
436.5	56.06	9,067
433.8	48.83	9,521
426.0	53.47	8,438
Average 434.9	55.72	8,164
Std. Dev. 16.1	4.83	1,556

TABLE D.48

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) WET

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #3				Tested by :	PM & DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-6	200°F (WET)	0.999	0.1203	7,598	63.22	8.047	7,939		1/23/90	(1,3,5,6,7)
BIL-GR-9-12	"	0.999	0.1197	7,715	64.50	8.091	7,603	0.085	9/13/89	(1,3,4,6)
BIL-GR-10-3	"	1.001	0.1132	8,169	72.13	7.596	6,929		1/23/90	(3,5,6,7,8)
BIL-GR-10-10	"	0.998	0.1197	7,705	64.47	8.027	5,339		9/14/89	(1,3,5,6)
BIL-GR-10-12	"	1.002	0.1181	7,019	59.31	7.014	8,540	0.066	1/23/90	(1,3,4,6)
BIL-GR-10-16	"	0.998	0.1122	7,202	64.31	8.766	5,522	0.048	9/13/89	(1,3,4,6)
			Average		64.66	7.923	6,979	0.067		
			Std. Dev.		4.16	0.583	1,308	0.018		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H.
(7) Tested without tabs.
(8) Failed at grip edge.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
435.9	55.48	7,939
444.7	55.79	7,603
497.3	52.37	6,929
444.5	55.34	5,339
409.0	48.36	8,540
443.4	60.44	5,522
Average	445.8	54.63	6,979
Std. Dev.	28.7	4.02	1,308

APPENDIX E
INDIVIDUAL SPECIMEN COMPRESSION PROPERTIES, BASELINE

The 48 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in compression. A summary of these data was presented and discussed in Section 3.2.2. Two types of compressive failure modes are referred to in this Appendix. Figure E.1 illustrates the type of failure behavior associated with each verbal description.

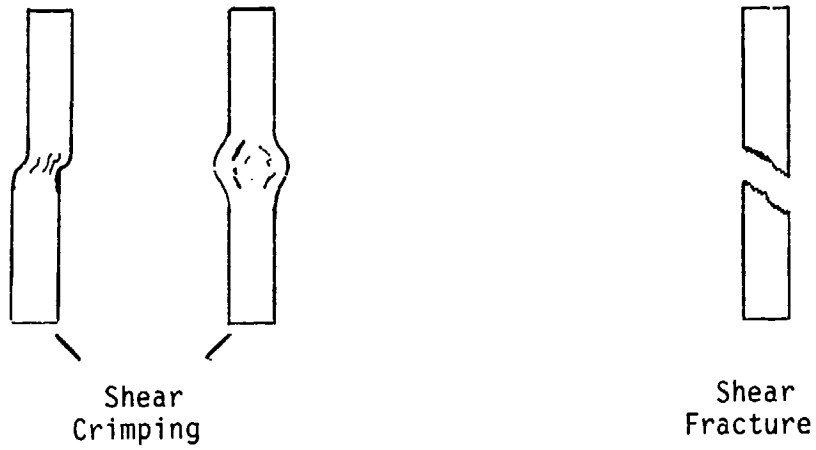


Figure E.1. Types of Compressive Failure Modes Observed.

TABLE E.1

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass			Batch #1	Task #4		Tested By:		PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-8-17	72°F (DRY)	1.001	0.1317	6,140	46.58	3.635	13,506	6/20/89	(1,4,5)
BIL-GL-8-19	"	0.998	0.1311	6,960	53.18	3.665	13,608	6/21/89	(1,4)
BIL-GL-8-22	"	1.003	0.1369	6,025	43.89	3.168	19,585	"	(1,2,4)
BIL-GL-8-24	"	1.004	0.1372	7,104	51.60	4.110	14,876	"	(1,4)
BIL-GL-8-25	"	1.003	0.1375	6,721	48.74	3.597	13,857	"	(1,4)
				Average	48.80	3.635	15,086		
				Std. Dev.	3.74	0.334	2,573		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(3) Failed outside gage section.
(4) Test speed = 0.05 in/min.
(5) Specimen did not fail; tab debonded.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
321.2	25.06	13,506
366.7	25.27	13,608
302.6	21.84	19,585
355.8	28.34	14,876
336.0	24.80	13,857
336.4	25.06	15,086
25.8	2.30	2,573

TABLE E.2

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410					Fiber Orientation:			Warp
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #4		Tested By:		PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-17	72°F (DRY)	1.003	0.1408	6,545	46.36	3.415	11,704	6/21/89	(1,3)
BIL-GL-9-19	"	1.003	0.1401	6,770	48.16	3.693	12,869	"	(1,3)
BIL-GL-9-22	"	1.000	0.1348	7,473	55.47	3.719	14,648	"	(1,3)
BIL-GL-9-24	"	1.000	0.1359	6,807	50.07	3.895	14,392	6/22/89	(1,3)
BIL-GL-9-25	"	0.998	0.1361	6,650	48.96	3.897	13,184	"	(1,3)
				Average	49.80	3.724	13,359		
				Std. Dev.	3.44	0.197	1,198		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
319.7	23.55	11,704
332.1	25.46	12,869
382.4	25.64	14,648
345.2	26.85	14,392
337.6	26.87	13,184
Average 343.4	25.68	13,359
Std. Dev. 23.7	1.36	1,198

TABLE E.3

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #3	Task #4			Tested By:		BH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-17	72°F (DRY)	1.003	0.1360	6,760	49.56	3.512	15,380	10/26/89	(1,3)
BIL-GL-10(R)-19	"	1.004	0.1320	6,430	48.52	3.735	16,500	"	(1,3)
BIL-GL-10(R)-22	"	1.002	0.1410	7,205	51.00	3.663	15,040	"	(1,3)
BIL-GL-10(R)-24	"	1.007	0.1370	7,215	52.30	3.842	16,600	"	(1,3)
BIL-GL-10(R)-25	"	1.003	0.1420	7,145	50.17	3.704	14,480	"	(1,3)
				Average	50.31	3.691	15,600		
				Std. Dev.	1.43	0.120	926		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
341.7	24.21	15,380
334.5	25.75	16,500
351.6	25.26	15,040
360.6	26.49	16,600
345.9	25.54	14,480
346.9	25.45	15,600
9.9	0.83	926

TABLE E.4

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #4			Tested By:	TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-8-18	72°F (WET)	1.003	0.1354	3,259	24.01	3.210	7,490	1/10/90	(1,3,4,5)
BIL-GL-8-21	"	1.005	0.1458	2,515	17.16	2.563	7,520	"	(1,3,4,5)
BIL-GL-8-23	"	1.002	0.1431	3,430	23.92	3.280	8,936	"	(1,3,4,5)
BIL-GL-8-26	"	1.007	0.1416	3,809	26.72	3.253	8,076	"	(1,3,4,5)
BIL-GL-8-28	"	1.002	0.1424	3,856	27.03	3.044	10,600	"	(1,3,4,5)
				Average	23.77	3.070	8,524		
				Std. Dev.	3.97	0.298	1,300		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
(5) Average weight gain = 1.9643%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	165.5	22.13	7,490
	118.3	17.67	7,520
	164.9	22.61	8,936
	184.3	22.43	8,076
	186.3	20.99	10,600
Average	163.9	21.17	8,524
Std. Dev.	27.4	2.05	1,300

TABLE E.5

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410					Fiber Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #4		Tested By:		TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-18	200°F (WET)	0.999	0.1454	2,295	15.80	3.132	5,166	12/5/89	(3,4,5)
BIL-GL-9-21	"	1.001	0.1400	1,636	11.68	2.969	5,469	"	(3,4,5)
BIL-GL-9-23	"	1.001	0.1395	2,100	15.04	3.074	4,775	"	(3,4,5)
BIL-GL-9-26	"	1.001	0.1396	1,953	13.98	2.763	6,572	"	(3,4,5)
BIL-GL-9-28	"	1.000	0.1400	1,794	12.82	3.307	4,160	"	(3,4,5)
				Average	13.86	3.049	5,229		
				Std. Dev.	1.66	0.202	896		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
(5) Average weight gain = 2.3264%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
108.9	21.60	5,166
80.5	20.47	5,469
103.7	21.19	4,775
96.4	19.05	6,572
88.4	22.80	4,160
Average 95.6	21.02	5,229
Std. Dev. 11.4	1.39	896

TABLE E.6

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #3	Task #4			Tested By:	RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-18	72°F (WET)	1.004	0.1350	3,418	25.22	3.395	8,262	1/5/90	(1,3,4,5)
BIL-GL-10(R)-21	"	1.001	0.1370	3,687	26.88	3.308	7,920	"	(1,3,4,5)
BIL-GL-10(R)-23	"	1.002	0.1410	3,711	26.27	2.921	10,495	"	(1,3,4,5)
BIL-GL-10(R)-26	"	1.002	0.1430	3,809	26.58	3.854	6,182	"	(1,3,4,5)
BIL-GL-10(R)-28	"	1.003	0.1420	3,174	22.28	3.618	5,850	"	(1,3,4,5)
				Average	25.45	3.419	7,742		
				Std. Dev.	1.88	0.350	1,864		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
(5) Average weight gain = 1.6754%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	173.9	23.41	8,262
	185.4	22.81	7,920
	181.1	20.14	10,495
	183.3	26.58	6,182
	153.6	24.94	5,850
Average	175.5	23.58	7,742
Std. Dev.	12.9	2.41	1,864

TABLE E.7

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) DRY

Test :	IITRI Compression; ASTM-D3410							Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #5				Tested By:	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-7-4	-65°F (DRY)	1.000	0.1325	8,671	65.43	4.042	19,170	5/1/89	(1,3)
BIL-GL-7-25	"	1.002	0.1361	9,293	68.15	3.903	16,545	"	(1,3)
BIL-GL-7-47	"	1.002	0.1309	8,979	68.46	4.139	16,935	"	(1,3)
BIL-GL-8-11	"	1.003	0.1359	7,898	57.92	4.057	17,512	6/22/89	(1,3)
BIL-GL-8-40	"	1.004	0.1385	8,450	60.75	3.924	17,395	"	(1,3)
				Average	64.14	4.013	17,511		
				Std. Dev.	4.65	0.099	1,004		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μm/m/cm)
451.2	27.87	19,170
469.9	26.91	16,545
472.0	28.54	16,935
399.4	27.98	17,512
418.9	27.06	17,395
Average 442.3	27.67	17,511
Std. Dev. 32.1	0.68	1,004

TABLE E.8

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) DRY

Test :	IITRI Compression, ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #5			Tested By:		PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-4	-65°F (DRY)	1.002	0.1380	7,969	57.61	4.138	15,960	6/22/88	(1,3)
BIL-GL-9-11	"	1.002	0.1329	7,429	55.80	4.348	13,433	"	(1,3)
BIL-GL-9-30	"	1.002	0.1339	7,683	57.25	4.545	14,070	"	(1,3)
BIL-GL-9-37	"	1.005	0.1361	8,171	59.77	3.626	14,971	"	(1,3)
BIL-GL-9-41	"	1.005	0.1360	7,854	57.47	4.276	14,678	"	(1,3)
				Average	57.58	4.187	14,622		
				Std. Dev.	1.42	0.346	953		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	397.2	28.53	15,960
	384.7	29.98	13,433
	394.7	31.34	14,070
	412.1	25.00	14,971
	396.2	29.48	14,678
Average	397.0	28.87	14,622
Std. Dev.	9.8	2.39	953

TABLE E.9

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #5		Tested By:		RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-1	-65°F (DRY)	1.002	0.1340	9,497	70.73	4.470	16,924	1/2/90	(1,3)
BIL-GL-10(R)-8	"	1.004	0.1380	8,984	64.84	4.211	18,994	"	(1,3)
BIL-GL-10(R)-15	"	1.001	0.1370	9,998	72.91	4.344	17,305	"	(1,3)
BIL-GL-10(R)-34	"	1.009	0.1370	10,156	73.47	4.363	20,800	"	(1,3)
BIL-GL-10(R)-43	"	1.006	0.1370	9,204	66.78	4.363	16,582	"	(1,3)
				Average	69.75	4.350	18,121		
				Std. Dev.	3.80	0.092	1,761		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
487.7	30.82	16,924
447.1	29.04	18,994
502.7	29.95	17,305
506.6	30.08	20,800
460.5	30.09	16,582
Average 480.9	30.00	18,121
Std. Dev. 26.2	0.64	1,761

TABLE E.10

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass	Batch #1	Task #5				Tested By:	PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-7-2	72°F (DRY)	1.001	0.1357	5,986	44.07	3.549	9,345	5/1/89	(1,4)
BIL-GL-7-23	"	1.002	0.1347	6,214	46.03	3.783	13,710	"	(1,2,4)
BIL-GL-7-45	"	1.002	0.1283	5,143	40.02	3.863	14,115	"	(1,2,4)
BIL-GL-8-9	"	1.004	0.1335	5,000	37.32	3.862	10,400	6/20/89	(1,4)
BIL-GL-8-38	"	1.001	0.1351	5,547	41.00	3.880	10,781	"	(1,2,4)
				Average	41.69	3.788	11,670		
				Std. Dev.	3.42	0.138	2,118		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(3) Specimen failed outside gage section.
(4) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
303.8	24.47	9,345
317.4	26.09	13,710
275.9	26.64	14,115
257.3	26.63	10,400
282.7	26.75	10,781
Average 287.4	26.12	11,670
Std. Dev. 23.6	0.95	2,118

TABLE E.11

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #5			Tested By.	PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-2	72°F (DRY)	1.004	0.1351	5,396	39.80	3.388	9,360	6/26/89	(1,3)
BIL-GL-9-9	"	1.002	0.1351	5,134	37.95	3.676	11,543	"	(1,3)
BIL-GL-9-16	"	1.004	0.1305	5,083	38.80	3.873	10,730	"	(1,3)
BIL-GL-9-35	"	1.003	0.1332	5,823	43.58	3.433	14,898	"	(1,3)
BIL-GL-9-44	"	1.003	0.1338	4,736	35.29	3.581	12,092	"	(1,3)
				Average	39.08	3.590	11,725		
				Std. Dev.	3.02	0.195	2,050		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
274.4	23.36	9,360
261.6	25.35	11,543
267.5	26.70	10,730
300.5	23.67	14,898
243.3	24.69	12,092
Average 269.5	24.75	11,725
Std. Dev. 20.8	1.35	2,050

TABLE E.12

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #3	Task #5			Tested By:	BH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-2	72°F (DRY)	1.002	0.1340	5,110	38.06	3.929	9,020	10/26/89	(1,3)
BIL-GL-10(R)-9	"	0.997	0.1370	5,510	40.34	3.130	17,800	"	(1,3)
BIL-GL-10(R)-16	"	1.001	0.1400	5,975	42.64	3.336	12,240	"	(1,3)
BIL-GL-10(R)-35	"	1.007	0.1390	6,310	45.08	3.715	11,420	"	(1,3)
BIL-GL-10(R)-44	"	1.006	0.1360	5,840	42.69	3.874	10,752	"	(1,3)
				Average	41.76	3.597	12,246		
				Std. Dev.	2.66	0.349	3,323		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	262.4	27.09	9,020
	278.1	21.58	17,800
	294.0	23.00	12,240
	310.8	25.61	11,420
	294.3	26.71	10,752
Average	287.9	24.80	12,246
Std. Dev.	18.4	2.41	3,323

TABLE E.13

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #5			Tested By:	PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
GL8-10	200°F (DRY)	1.004	0.1345	3,805	28.17	3.530	9,360	6/26/89	(1,3)
GL8-39	"	1.004	0.1382	3,848	27.72	3.412	9,119	"	(1,3)
				Average	27.95	3.471	9,240		
				Std. Dev.	0.32	0.083	171		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear Fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	194.3	24.34	9,360
	191.2	23.53	9,119
Average	192.7	23.93	9,240
Std. Dev.	2.2	0.58	171

TABLE E.14

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #5		Tested By:		PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-3	200°F (DRY)	1.003	0.1375	3,225	23.39	3.753	7,280	6/23/89	(1,3)
BIL-GL-9-10	"	1.002	0.1320	3,318	25.09	3.373	7,537	"	(1,3)
BIL-GL-9-09	"	1.003	0.1265	2,975	23.45	3.399	6,658	"	(2,3)
BIL-GL-9-06	"	1.003	0.1359	3,661	26.85	3.257	9,229	"	(1,3)
BIL-GL-9-40	"	1.006	0.1377	3,656	26.39	2.985	6,548	"	(1,3)
				Average	25.04	3.353	7,450		
				Std. Dev.	1.61	0.277	1,077		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
161.3	25.88	7,280
173.0	23.25	7,537
161.7	23.44	6,658
185.2	22.46	9,229
182.0	20.58	6,548
172.6	23.12	7,450
11.1	1.91	1,077

TABLE E.15

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #3	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-3	200°F (DRY)	1.009	0.1350	4,248	31.19	3.827	7,500	1/2/90	(1,3)
BIL-GL-10(R)-10	"	0.997	0.1380	4,712	34.25	3.244	12,412	"	(1,3)
BIL-GL-10(R)-29	"	0.998	0.1350	4,346	32.25	3.752	8,369	"	(1,3)
BIL-GL-10(R)-36	"	1.011	0.1390	4,529	32.23	3.621	9 775	"	(1,3)
BIL-GL-10(R)-40	"	1.010	0.1350	5,075	37.22	3.667	10,070	"	(1,3)
				Average	33.43	3.622	9,625		
				Std. Dev.	2.39	0.226	1,876		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	215.0	26.39	7,500
	236.1	22.37	12,412
	222.4	25.87	8,369
	222.2	24.97	9,775
	256.6	25.28	10,070
Average	230.5	24.98	9,625
Std. Dev	16.5	1.56	1,876

TABLE E.16

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410							Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #5				Tested By:	TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-7-1	-65°F (WET)	1.001	0.1306	5,906	45.17	4.111	10,450	1/10/90	(1,3,4,5)
BIL-GL-7-22	"	1.000	0.1351	7,019	51.94	4.295	13,848	"	(1,3,4,5)
BIL-GL-7-44	"	1.002	0.1306	6,482	49.55	4.171	10,313	"	(1,3,4,5)
BIL-GL-8-8	"	1.004	0.1385	5,786	41.61	4.130	12,969	"	(1,3,4,6)
BIL-GL-8-37	"	1.003	0.1425	6,200	43.40	3.872	13,400	"	(1,3,4,6)
				Average	46.34	4.116	12,196		
				Std. Dev.	4.30	0.154	1,686		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
(5) Weight gain = 1.6916%
(6) Weight gain = 1.9759%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
311.5	28.35	10,450
358.1	29.61	13,848
341.7	28.76	10,313
286.9	28.48	12,969
299.2	26.70	13,400
Average 319.5	28.38	12,196
Std. Dev. 29.7	1.06	1,686

TABLE E.17

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-1	-65°F (WET)	1.002	0.1341	5,322	39.61	3.783	9,893	1/10/90	(1,3,4,5)
BIL-GL-9-8	"	1.002	0.1376	6,113	44.33	3.876	10,685	"	(1,3,4,5)
BIL-GL-9-15	"	1.002	0.1419	5,481	38.55	3.410	12,324	"	(1,3,4,5)
BIL-GL-9-34	"	1.003	0.1393	6,433	46.04	4.359	11,289	"	(1,3,4,5)
BIL-GL-9-43	"	1.002	0.1394	6,628	47.44	3.975	12,461	"	(1,3,4,5)
				Average	43.19	3.881	11,330		
				Std. Dev.	3.93	0.342	1,090		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
(5) Weight gain = 2.0685%

SI Conversion

	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	273.1	26.08	9,893
	305.7	26.72	10,685
	265.8	23.51	12,324
	317.4	30.06	11,289
	327.1	27.41	12,461
Average	297.8	26.76	11,330
Std. Dev.	27.1	2.36	1,090

TABLE E.18

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #5		Tested By:		RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-4	-65°F (WET)	1.004	0.1360	6,836	50.06	4.221	13,916	1/10/90	(1,3,4,5)
BIL-GL-10(R)-11	"	0.995	0.1370	7,642	56.06	3.984	15,693	"	(1,3,4,5)
BIL-GL-10(R)-30	"	1.001	0.1340	6,299	46.96	4.459	13,721	"	(1,3,4,5)
BIL-GL-10(R)-37	"	1.005	0.1370	6,580	47.79	4.046	11,777	"	(1,3,4,5)
BIL-GL-10(R)-41	"	1.004	0.1370	6,750	49.08	4.427	13,057	"	(1,3,4,5)
				Average	49.99	4.227	13,633		
				Std. Dev.	3.60	0.215	1,424		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
(5) Weight gain = 1.7721%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	345.2	29.11	13,916
	386.5	27.47	15,693
	323.8	30.74	13,721
	329.5	27.90	11,777
	338.4	30.52	13,057
Average	344.7	29.15	13,633
Std. Dev.	24.8	1.48	1,424

TABLE E.19

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-7-5	72°F (WET)	1.001	0.1308	3,174	24.24	3.385	6,172	1/4/90	(1,3,4,5)
BIL-GL-7-26	"	1.000	0.1345	3,186	23.70	3.276	8,945	"	(1,3,4,5)
BIL-GL-7-48	"	1.003	0.1301	2,466	18.90	3.320	8,750	"	(1,3,4,5)
BIL-GL-8-12	"	1.004	0.1422	2,991	20.94	3.335	4,570	"	(1,3,4,6)
BIL-GL-8-41	"	1.004	0.1415	2,763	19.44	3.232	8,480	"	(1,3,4,6)
				Average	21.44	3.310	7,384		
				Std. Dev.	2.43	0.058	1,929		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
(5) Weight gain = 1.4829%
(6) Weight gain = 2.1793%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	167.1	23.34	6,172
	163.4	22.59	8,945
	130.3	22.89	8,750
	144.4	23.00	4,570
	134.0	22.29	8,480
Average	147.9	22.82	7,384
Std. Dev.	16.8	0.40	1,929

TABLE E.20

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #5		Tested By:		RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-5	72°F (WET)	1.003	0.1360	3,137	23.00	3.490	9,307	1/9/90	(1,3,4,5)
BIL-GL-10(R)-12	"	0.992	0.1390	3,821	27.71	4.568	7,314	"	(1,3,4,5)
BIL-GL-10(R)-31	"	1.001	0.1370	3,394	24.75	3.261	7,949	"	(1,3,4,5)
BIL-GL-10(R)-38	"	1.006	0.1380	3,638	26.20	3.355	8,789	"	(1,3,4,5)
BIL-GL-10(R)-42	"	1.005	0.1370	3,681	26.74	3.405	7,710	"	(1,3,4,5)
				Average	25.68	3.616	8,214		
				Std. Dev.	1.84	0.539	815		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0 05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
(5) Weight gain = 1.7721%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
158.6	24.06	9,307
191.1	31.50	7,314
170.6	22.49	7,949
180.7	23.13	8,789
184.3	23.47	7,710
Average 177.1	24.93	8,214
Std. Dev. 12.7	3.71	815

TABLE E.21

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #5			Tested By:		TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-7-6	200°F (WET)	1.001	0.1335	1,917	14.34	3.160	4,609	12/4/89	(3,4,5)
BIL-GL-7-27	"	0.999	0.1333	1,978	14.85	3.373	4,326	"	(3,4,5)
BIL-GL-8-13	"	1.002	0.1376	1,697	12.30	3.585	3,896	"	(3,4,6)
BIL-GL-8-42	"	1.002	0.1401	1,953	13.91	2.827	5,140	"	(3,4,6)
				Average	13.85	3.236	4,493		
				Std. Dev.	1.10	0.323	521		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
(5) Weight gain = 1.6563%
(6) Weight gain = 2.0359%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	98.9	21.79	4,609
	102.4	23.25	4,326
	84.8	24.72	3,896
	95.9	19.49	5,140
Average	95.5	22.31	4,493
Std. Dev.	7.6	2.23	521

TABLE E.22

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #5			Tested By:		TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-6	200°F (WET)	1.003	0.1384	1,721	12.39	2.544	5,352	12/4/89	(1,3,4,5)
BIL-GL-9-13	"	1.004	0.1392	1,721	12.31	2.806	4,268	"	(1,3,4,5)
BIL-GL-9-32	"	1.003	0.1421	1,953	13.70	3.330	3,838	"	(1,3,4,5)
BIL-GL-9-39	"	1.005	0.1405	1,672	11.84	3.017	3,691	"	(1,3,4,5)
BIL-GL-9-33	"	1.002	0.1420	2,283	16.04	2.316	6,895	1/18/90	(1,3,4,5)
				Average	13.26	2.803	4,809		
				Std. Dev.	1.70	0.396	1,335		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
(5) Weight gain = 1.9580%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
85.5	17.54	5,352
84.9	19.35	4,268
94.4	22.96	3,838
81.7	20.81	3,691
110.6	15.97	6,895
91.4	19.32	4,809
11.7	2.73	1,335

TABLE E.23

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #2	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-9-5	200°F (WET)	1.001	0.1362	1,850	13.56	2.979	3,620	12/5/89	(3,4,5,6)
BIL-GL-9-12	"	1.002	0.1358	1,721	12.65	2.862	4,189	"	(3,4,5,6)
BIL-GL-9-31	"	1.003	0.1404	1,660	11.80	3.606	3,320	"	(3,4,5,6)
BIL-GL-9-38	"	1.005	0.1395	1,782	12.72	2.958	5,500	"	(3,4,5,6)
BIL-GL-9-42	"	1.002	0.1400	1,863	13.28	2.897	4,150	"	(3,4,5,6)
				Average	12.80	3.060	4,156		
				Std. Dev.	0.68	0.308	836		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
(5) Weight gain = 2.3254%
(6) These specimens were supposed to have been tested at 72°F(Wet) condition. They were inadvertently tested at 200°F(Wet).

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
93.5	20.54	3,620
37.2	19.73	4,189
81.3	24.86	3,320
87.7	20.39	5,500
91.6	19.98	4,150
Average 88.3	21.10	4,156
Std. Dev. 4.3	2.13	836

TABLE E.24

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410					Fiber Orientation:			Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #5		Tested By:		TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GL-10(R)-6	200°F (WET)	1.003	0.1370	2,515	18.30	3.673	4,238	1/9/90	(1,3,4,5)
BIL-GL-10(R)-32	"	1.001	0.1390	2,515	18.07	3.915	2,881	"	(1,3,4,5)
BIL-GL-10(R)-33	"	1.005	0.1380	2,234	16.11	2.767	5,801	"	(1,3,4,5)
BIL-GL-10(R)-39	"	1.006	0.1400	2,393	16.99	2.736	5,986	"	(1,3,4,5)
				Average	17.37	3.273	4,727		
				Std. Dev.	1.02	0.610	1,459		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
(5) Weight gain = 1.7721%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	126.2	25.33	4,238
	124.6	26.99	2,881
	111.1	19.08	5,801
	117.1	18.86	5,986
Average	119.7	22.57	4,727
Std. Dev.	7.0	4.21	1,459

TABLE E.25

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #4			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-14-22	72°F (DRY)	1.003	0.1905	14,392	75.34	8.388	8,720	11/14/89	(1,3)
BIL-GR-14-24	"	1.004	0.1817	10,300	56.44	8.289	7,330	"	(1,3)
BIL-GR-14-25	"	1.003	0.1908	12,830	67.02	6.333	12,830	"	(1,3)
				Average	66.27	7.670	9,627		
				Std. Dev.	9.47	1.159	2,860		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
519.5	57.84	8,720
389.2	57.15	7,330
462.1	43.67	12,830
Average 456.9	52.88	9,627
Std. Dev. 65.3	7.99	2,860

TABLE E.26

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #2	Task #4				Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-17	72°F (DRY)	1.001	0.1790	13,288	74.16	8.441	10,580	11/15/89	(1,3)
BIL-GR-15-19	"	1.002	0.1800	14,163	78.52	9.363	8,330	"	(1,3)
BIL-GR-15-22	"	1.003	0.1840	12,263	66.44	8.399	7,150	"	(1,3)
BIL-GR-15-24	"	1.002	0.1830	13,363	72.87	7.226	7,580	"	(1,3)
BIL-GR-15-25	"	1.003	0.1770	12,122	68.28	10.245	6,670	"	(1,3)
				Average	72.06	8.735	8,062		
				Std. Dev.	4.81	1.135	1,534		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
511.3	58.20	10,580
541.4	64.56	8,330
458.1	57.91	7,150
502.5	49.82	7,580
470.8	70.64	6,670
496.8	60.23	8,062
33.2	7.82	1,534

TABLE E.27

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :	IITRI Compression: ASTM-D3410						Fiber Orientation:	Warp
Materia. :	EA-9396 A/B; W133 Graphite		Batch #3	Task #4			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-17	72°F (DRY)	1.001	0.1810	12,183	67.24	7.927	9,380	11/15/89	(1,3)
BIL-GR-16-19	"	1.001	0.1830	13,425	73.29	10.236	7,680	"	(1,3)
BIL-GR-16-22	"	1.001	0.1850	12,475	67.37	8.843	6,800	"	(1,3)
BIL-GR-16-24	"	1.002	0.1820	13,063	71.63	6.154	14,268+	"	(1,3)
				Average	69.88	8.290	9,532+		
				Std. Dev.	3.05	1.711	3,334+		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	463.6	54.66	9,380
	505.3	70.57	7,680
	464.5	60.97	6,800
	493.9	42.43	14,268+
Average	481.8	57.16	9,532+
Std. Dev.	21.1	11.80	3,334+

TABLE E.28

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #4				Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-14--18	72°F (WET)	0.994	0.1867	11,163	60.17	8.008	6,570	1/12/90	(1,3,4,5)
BIL-GR-14-21	"	1.001	0.1900	12,450	65.43	6.660	12,285	"	(1,3,4,5)
BIL-GR-14-23	"	0.998	0.1914	8,081	42.30	7.438	5,762	"	(1,3,4,5)
BIL-GR-14-26	"	1.006	0.1854	10,852	58.20	8.117	7,246	"	(1,3,4,5)
BIL-GR-14-28	"	1.003	0.1881	11,600	61.47	7.286	9,700	"	(1,3,4,5)
				Average	57.51	7.502	8,313		
				Std. Dev.	8.91	0.590	2,664		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95–100% R.H. for 99 days.
(5) Weight gain = 2.4270%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
414.9	55.21	6,570
451.2	45.92	12,285
291.6	51.28	5,762
401.3	55.97	7,246
423.8	50.24	9,700
Average 396.5	51.72	8,313
Std. Dev. 61.4	4.07	2,664

TABLE E.29

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #2	Task #4				Tested By:	RG

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-18	72°F (WET)	1.001	0.1790	9,985	55.73	9.178	5,889	1/12/90	(1,3,4,5)
BIL-GR-15-21	"	1.002	0.1820	9,387	51.48	9.142	6,270	"	(1,3,4,5)
BIL-GR-15-23	"	1.003	0.1840	9,705	52.58	6.442	10,420	"	(1,3,4,5)
BIL-GR-15-26	"	1.002	0.1760	10,193	57.80	7.811	6,963	"	(1,3,4,5)
BIL-GR-15-28	"	1.003	0.1770	8,997	50.68	7.216	7,441	"	(1,3,4,5)
				Average	53.65	7.958	7,397		
				Std. Dev.	3.01	1.200	1,794		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95–100% R.H. for 99 days.
(5) Weight gain = 2.2206%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
384.2	63.29	5,889
354.9	63.03	6,270
362.6	44.42	10,420
398.5	53.86	6,963
349.4	49.75	7,441
Average 369.9	54.87	7,397
Std. Dev. 20.8	8.27	1,794

TABLE E.30

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #4			Tested By:	TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-18	72°F (WET)	1.002	0.1830	9.180	50.06	6.051	9,111	1/4/90	(1,3,4,5)
BIL-GR-16-21	"	1.002	0.1860	9.802	52.60	6.661	10,300	"	(1,3,4,5)
BIL-GR-16-23	"	1.002	0.1840	9.595	52.04	8.848	6,084	"	(1,3,4,5)
BIL-GR-16-26	"	1.001	0.1830	8.630	47.11	9.209	5,410	"	(1,3,4,5)
BIL-GR-16-28	"	1.002	0.1790	9.009	50.23	7.507	8,130	"	(1,3,4,5)
				Average	50.41	7.655	7,807		
				Std. Dev.	2.15	1.362	2,045		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
(5) Weight gain = 2.1824%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
345.2	41.72	9,111
362.6	45.93	10,300
358.8	61.01	6,084
324.8	63.50	5,410
346.3	51.76	8,130
347.6	52.78	7,807
14.8	9.39	2,045

TABLE E.31

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #5			Tested By:	BH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus - (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-1	-65°F (DRY)	0.998	0.1680	13,123	78.27	8.946	8,400	11/6/89	(1,3)
BIL-GR-13-22	"	1.001	0.1830	15,963	87.14	11.191	8,860	"	(1,3)
BIL-GR-13-44	"	1.000	0.1810	16,513	91.23	8.910	12,040	11/13/89	(1,3)
BIL-GR-14-8	"	1.003	0.1804	15,763	87.14	8.949	10,670	11/6/89	(1,3)
BIL-GR-14-37	"	1.000	0.1822	15,650	85.87			"	(1,3,4)
				Average	85.93	9.499	9,993		
				Std. Dev.	4.74	1.128	1,680		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
539.7	61.69	8,400
600.8	77.16	8,860
629.0	61.44	12,040
600.8	61.70	10,670
592.1		
Average 592.5	65.50	9,993
Std. Dev. 32.7	7.78	1,680

TABLE E.32

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #2	Task #5			Tested By:		BH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-1	-65°F (DRY)	1.000	0.1724	12,338	71.53	8.806	8,230	10/31/89	(1,3)
BIL-GR-15-15	"	1.004	0.1766	12,513	70.60	7.899	12,490	11/2/89	(1,3)
BIL-GR-15-34	"	1.000	0.1790	15,250	85.21	7.728	12,850	"	(1,3)
BIL-GR-15-43	"	1.007	0.1738	13,725	78.44	8.109	12,891	10/31/89	(1,3)
BIL-GR-15-8	"	1.004	0.1724	13,725	79.28			"	(1,3,4)
				Average	77.01	8.135	11,615		
				Std. Dev.	6.03	0.473	2,264		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
493.2	60.72	8,230
486.8	54.46	12,490
587.5	53.29	12,850
540.9	55.91	12,891
546.6		
Average 531 0	56.09	11,615
Std. Dev. 41.6	3.26	2,264

TABLE E.33

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #5			Tested By:		BH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-1	-65°F (DRY)	1.001	0.1732	14,771	85.18	8.255	11,934	11/6/89	(1,3)
BIL-GR-16-8	"	1.001	0.1821	16,463	90.36	7.547	13,400	"	(1,3)
BIL-GR-16-15	"	1.004	0.1796	16,438	91.14	7.381	13,590	"	(1,3)
BIL-GR-16-34	"	1.006	0.1783	16,126	89.95	8.367	12,300	"	(1,3)
BIL-GR-16-43	"	1.003	0.1754	13,367	75.97	7.886	14,014	"	(1,3)
				Average	86.52	7.887	13,047		
				Std. Dev.	6.34	0.429	888		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
587.3	56.92	11,934
623.0	52.04	13,400
628.4	50.89	13,590
620.2	57.69	12,300
523.8	54.37	14,014
596.5	54.38	13,047
43.7	2.96	888

TABLE E.34

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) DRY

Test : IITRI Compression; ASTM-D3410

Material : EA-9396 A/B; W133 Graphite Batch #1 Task #5 Fiber Orientation: Fill

Tested By: BH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-2	72°F (DRY)	0.998	0.1720	10,088	58.77	8.229	8,100	10/26/89	(1,3,4)
BIL-GR-13-23	"	1.001	0.1840	9,838	53.41	5.938	8,380	"	(1,3)
BIL-GR-13-45	"	1.001	0.1824	11,694	64.02	8.361	6,377	12/15/89	(1,3)
BIL-GR-14-9	"	1.002	0.1802	10,675	59.13	7.097	8,450	"	(1,3)
BIL-GR-14-38	"	1.001	0.1824	11,888	65.08	7.733	8,290	11/2/89	(1,3)
				Average	60.08	7.471	7,919		
				Std. Dev.	4.68	0.990	872		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Tabs debonded.

SI Conversion

Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
405.2	56.74	8,100
368.3	40.94	8,380
441.4	57.65	6,377
407.7	48.93	8,450
448.7	53.32	8,290
Average 414.3	51.52	7,919
Std. Dev. 32.3	6.83	872

TABLE E.35

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #2	Task #5			Tested By:	BH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-2	72°F (DRY)	1.003	0.1753	11,388	64.79	9.210	7,640	10/31/89	(1,3)
BIL-GR-15-9	"	1.002	0.1783	10,488	58.70	8.500	6,580	"	(1,3)
BIL-GR-15-35	"	1.000	0.1772	11,013	62.15	7.443	10,590	"	(1,3)
BIL-GR-15-44	"	1.007	0.1710	9,000	52.29	8.133	7,780	"	(1,3)
				Average	59.48	8.322	8,148		
				Std. Dev.	5.41	0.737	1,714		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
446.7	63.50	7,640
404.7	58.61	6,580
428.5	51.32	10,590
360.5	56.08	7,780
Average 410.1	57.4	8,148
Std. Dev. 37.3	5.1	1,714

TABLE E.36

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-2	72°F (DRY)	1.002	0.1767	11,425	64.56	7.707	13,926	11/13/89	(1,3)
BIL-GR-16-9	"	1.004	0.1821	11,275	61.66	6.905	10,300	"	(1,3)
BIL-GR-16-16	"	1.004	0.1798	11,838	65.59	8.588	7,270	"	(1,3)
BIL-GR-16-35	"	1.006	0.1810	10,632	58.37	7.720	5,580	"	(1,3)
BIL-GR-16-44	"	1.003	0.1735	11,304	64.98	8.489	6,416	12/15/89	(1,3)
				Average	63.03	7.882	8,698		
				Std. Dev.	3.01	0.685	3,423		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion

Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
445.1	53.14	13,926
425.2	47.61	10,300
452.2	59.21	7,270
402.5	53.23	5,580
448.0	58.53	6,416
Average 434.6	54.34	8,698
Std. Dev. 20.8	4.73	3,423

TABLE E.37

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #5			Tested By:		RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-3	200°F (DRY)	0.997	0.1760	7,363	41.96	8.691	4,830	11/15/89	(1,3,4)
BIL-GR-13-24	"	0 998	0.1840	8,413	45.81	8.237	5,254	"	(1,3)
BIL-GR-13-46	"	1.001	0.1790	7,800	43.53	8.957	4,350	"	(1,3)
BIL-GR-14-10	"	1.002	0.1804	7,642	42.28	7.180	7,120	"	(1,3)
BIL-GR-14-39	"	1.001	0.1799	7,947	44.13	7.496	5,156	11/16/89	(1,3)
				Average	43.54	8.112	5,342		
				Std. Dev.	1.55	0.760	1,055		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Tabs debonded.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
289.3	59.92	4,830
315.9	56.79	5,254
300.2	61.76	4,350
291.5	49.51	7,120
304.3	51.69	5,156
Average 300.2	55.93	5,342
Std. Dev. 10.7	5.24	1,055

TABLE E.38

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) DRY

Test : IITRI Compression; ASTM-D3410

Material : EA-9396 A/B; W133 Graphite Batch #2 Task #5 Fiber Orientation: Fill

Tested By: TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-3	200°F (DRY)	0.998	0.1772	7,141	40.40	9.564	3,779	11/16/89	(1,3)
BIL-GR-15-10	"	1.002	0.1783	7,031	39.34	6.461	5,957	"	(1,3)
BIL-GR-15-29	"	1.002	0.1697	5,975	35.15	7.905	4,200	"	(1,3)
BIL-GR-15-36	"	1.000	0.1769	6,363	35.96	9.446	3,590	"	(1,3)
BIL-GR-15-40	"	1.006	0.1736	6,213	35.59	7.447	5,030	"	(1,3)
				Average	37.29	8.164	4,511		
				Std. Dev.	2.40	1.331	980		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion

Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
278.5	65.94	3,779
271.3	44.55	5,957
242.4	54.50	4,200
248.0	65.13	3,590
245.4	51.35	5,030
Average 257.1	56.29	4,511
Std. Dev. 16.5	9.18	980

TABLE E.39

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #5			Tested By:	RG

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-3	200°F (DRY)	1.001	0.1797	7,471	41.55	7.636	7,610	11/16/89	(1,3)
BIL-GR-16-10	"	1.004	0.1804	7,738	42.70	7.102	5,566	"	(1,3)
BIL-GR-16-29	"	1.006	0.1706	6,625	38.62	7.778	6,220	"	(1,3)
BIL-GR-16-36	"	1.007	0.1778	7,166	40.03	7.612	6,210	"	(1,3)
BIL-GR-16-40	"	1.006	0.1774	7,043	39.47	7.741	5,479	"	(1,3)
				Average	40.48	7.574	6,217		
				Std. Dev.	1.64	0.273	853		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	286.5	52.65	7,610
	294.4	48.97	5,566
	266.3	53.63	6,220
	276.0	52.49	6,210
	272.2	53.38	5,479
Average	279.1	52.22	6,217
Std. Dev.	11.3	1.88	853

TABLE E.40

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #5			Tested By:	RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-4	-65°F (WET)	0.996	0.1750	12,268	70.38	8.831	8,311	1/16/90	(1,3,4,5,6)
BIL-GR-13-25	"	0.994	0.1840	15,735	86.03	9.315	9,600	"	(1,3,5,6)
BIL-GR-13-47	"	1.000	0.1760	13,538	76.92	10.211	7,500	"	(1,3,5,6)
BIL-GR-14-11	"	1.002	0.1809	13,538	74.66	8.401	9,189	"	(1,3,5,7)
BIL-GR-14-40	"	1.001	0.1767	13,806	78.09	9.139	14,072	"	(1,3,5,7)
				Average	78.92	9.179	10,090		
				Std. Dev.	4.95	0.673	2,806		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Tabs debonded. Not included in average strength or ultimate strain.
(5) Specimens aged @ 140°F/95-100% R.H. for 99 days.
(6) Weight gain = 2.3016%
(7) Weight gain = 2.4270%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	485.3	60.89	8,311
	593.2	64.23	9,600
	530.4	70.40	7,500
	514.7	57.93	9,189
	538.4	63.01	14,072
Average	544.2	63.29	10,090
Std. Dev.	34.1	4.64	2,806

TABLE E.41

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #5		Tested By:		RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-4	-65°F (WET)	1.004	0.1781	13,074	73.10	8.390	10,039	11/16/89	(1,3,4,5)
BIL-GR-15-11	"	1.004	0.1791	14,612	81.27	8.426	10,273	"	(1,3,4,5)
BIL-GR-15-30	"	1.004	0.1732	12,940	74.45	8.671	11,729	"	(1,3,4,5)
BIL-GR-15-37	"	1.007	0.1756	13,330	75.38	8.635	8,486	"	(1,3,4,5)
BIL-GR-15-41	"	1.006	0.1717	11,853	68.59	8.897	11,853	"	(1,3,4,5)
				Average	74.56	8.604	10,476		
				Std. Dev.	4.57	0.206	1,383		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
(5) Weight gain = 2.2206%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	504.0	57.85	10,039
	560.3	58.09	10,273
	513.3	59.79	11,729
	519.7	59.54	8,486
	473.0	61.35	11,853
Average	514.1	59.32	10,476
Std. Dev.	31.5	1.42	1,383

TABLE E.42

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #5		Tested By:		BH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-4	-65°F (WET)	1.001	0.1819	15,283	83.97	9.062	9,336	1/11/90	(1,3,4,5)
BIL-GR-16-11	"	1.006	0.1806	14,356	79.02	8.186	9,854	"	(1,3,4,5)
BIL-GR-16-30	"	1.006	0.1755	11,938	67.61	8.247	7,720	"	(1,3,4,5)
BIL-GR-16-37	"	1.004	0.1757	14,941	84.73	8.394	12,315	"	(1,3,4,5)
BIL-GR-16-41	"	1.005	0.1759	12,756	72.16	9.129	7,461	"	(1,3,4,5)
				Average	77.50	8.604	9,337		
				Std. Dev.	7.46	0.456	2,256		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
(5) Weight gain = 2.1824%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	579.0	62.48	9,336
	544.9	56.44	9,854
	466.2	56.87	7,720
	584.2	57.88	12,315
	497.5	62.94	7,461
Average	534.4	59.32	9,337
Std. Dev.	51.5	3.14	2,256

TABLE E.43

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-5	72°F (WET)	0.999	0.1770	9,650	54.57	9.225	5,350	12/6/89	(1,3,4,5)
BIL-GR-13-26	"	0.996	0.1860	11,100	59.92	8.805	7,340	"	(1,3,4,5)
BIL-GR-13-48	"	0.998	0.1760	8,275	47.11	9.109	5,230	"	(1,3,4,5)
BIL-GR-14-12	"	1.002	0.1774	9,188	51.70	8.934	5,870	"	(1,3,4,6)
BIL-GR-14-41	"	1.001	0.1761	9,167	52.00	8.515	5,674	"	(1,3,4,6)
				Average	53.06	8.918	5,893		
				Std. Dev.	4.68	0.277	848		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 2.2390%
(6) Weight gain = 2.0377%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	376.3	63.61	5,350
	413.1	60.71	7,340
	324.8	62.81	5,230
	356.5	61.60	5,870
	358.5	58.71	5,674
Average	365.9	61.49	5,893
Std. Dev.	32.3	1.91	848

TABLE E.44

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410					Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #2	Task #5		Tested By:		TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-5	72°F (WET)	1.005	0.1797	8,716	48.25	6.563	6,738	12/6/89	(1,3,4,5)
BIL-GR-15-12	"	1.004	0.1755	8,850	50.25	7.389	6,390	"	(1,3,4,5)
BIL-GR-15-31	"	1.003	0.1757	8,911	50.55	7.025	12,900	"	(1,3,4,5)
BIL-GR-15-38	"	1.007	0.1749	8,801	49.95	8.432	5,664	"	(1,3,4,5)
BIL-GR-15-42	"	1.007	0.1715	8,008	46.36	9.337	5,137	12/11/89	(1,3,4,5)
				Average	49.07	7.749	7,366		
				Std. Dev.	1.76	1.123	3,156		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 1.9091%

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
332.7	45.26	6,738
346.5	50.95	6,390
348.5	48.44	12,900
344.4	58.14	5,664
319.6	64.38	5,137
Average 338.4	53.43	7,366
Std. Dev. 12.1	7.74	3,156

TABLE E.45

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #5			Tested By:	TB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-5	72°F (WET)	1.001	0.1788	9,338	52.19	7.488	6,826	12/11/89	(1b,3,4,5)
BIL-GR-16-12	"	1.005	0.1812	9,570	52.55	7.587	6,299	"	(1b,3,4,5)
BIL-GR-16-31	"	1.007	0.1779	8,179	45.66	8.043	8,350	"	(1b,3,4,5)
BIL-GR-16-38	"	1.005	0.1794	9,937	55.13	8.590	7,334	"	(1b,3,4,5)
BIL-GR-16-42	"	1.005	0.1762	7,861	44.39	8.538	4,961	"	(1a,3,4,5)
				Average	49.98	8.049	6,754		
				Std. Dev.	4.69	0.515	1,256		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (1a) Shear fracture
  (1b) Shear crimping
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 2.0033%

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	359.8	51.63	6,826
	362.3	52.31	6,299
	314.8	55.46	8,350
	380.1	59.23	7,334
	306.1	58.87	4,961
Average	344.6	55.50	6,754
Std. Dev.	32.3	3.55	1,256

TABLE E.46

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #5			Tested By:	RG

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-13-6	200°F (WET)	1.000	0.1780	3,516	19.75	10.689	1,934	11/29/89	(3,4,5,7,8)
BIL-GR-13-43	"	0.998	0.1840	4,944	26.92	9.817	2,959	11/30/89	(1b,3,4,5,8)
BIL-GR-14-13	"	1.003	0.1774	4,480	25.18	8.718	2,520	12/1/89	(1a,3,4,6,8)
BIL-GR-14-42	"	1.002	0.1768	4,541	25.64	9.580	2,529	11/30/89	(1a,3,4,6,8)
				Average	24.37	9.701	2,485		
				Std. Dev.	3.17	0.810	421		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (1a) Shear fracture
  (1b) Shear crimping
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 2.2390%
(6) Weight gain = 2.0377%
(7) Tabs debonded.
(8) Tested without tabs.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
136.2	73.70	1,934
185.6	67.68	2,959
173.6	60.11	2,520
176.8	66.05	2,529
Average 165.1	67.16	2,485
Std. Dev. 25.8	6.81	421

TABLE E.47

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #2	Task #5			Tested By:	RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-15-6	200°F (WET)	1.005	0.1791	4,919	27.32	7.701	3,262	11/30/89	(1b,3,4,5,6)
BIL-GR-15-13	"	1.000	0.1739	5,825	33.50	7.365	5,127	12/4/89	(1a,3,4,5,6)
BIL-GR-15-32	"	1.003	0.1765	3,833	21.66	9.152	2,295	11/30/89	(1a,3,4,5,6)
BIL-GR-15-33	"	1.000	0.1787	5,611	31.40	8.128	4,023	12/4/89	(1a,3,4,5,6)
BIL-GR-15-39	"	1.007	0.1742	4,236	24.15	8.386	4,210	11/30/89	(1a,3,4,5,6)
				Average	27.61	8.146	3,783		
				Std. Dev.	4.91	0.685	1,064		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (1a) Shear fracture
  (1b) Shear crimping
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 1.9091%
(6) Tested without tabs.

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
188.4	53.10	3,262
231.0	50.78	5,127
149.3	63.10	2,295
216.5	56.04	4,023
166.5	57.82	4,210
Average 190.3	56.17	3,783
Std. Dev. 33.9	4.73	1,064

TABLE E.48

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #3	Task #5			Tested By:	RG
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Date Tested	Remarks
BIL-GR-16-6	200°F (WET)	1.002	0.1791	5,432	30.28	7.548	4,482	11/30/89	(1,3,4,5,7)
BIL-GR-16-13	"	1.005	0.1807	6,738	37.12	8.469	4,375	12/4/89	(1,3,4,5,7)
BIL-GR-16-32	"	1.005	0.1789	5,750	31.97	8.235	4,004	11/30/89	(1,3,4,5,7)
BIL-GR-16-39	"	1.005	0.1780	5,298	29.61	9.731	2,939	"	(1,3,4,5,6,7)
				Average	32.24	8.495	3,950		
				Std. Dev.	3.40	0.912	704		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
(5) Weight gain = 2.0033%
(6) Tested without tabs.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	208.8	52.04	4,482
	255.9	58.39	4,375
	220.4	56.78	4,004
	204.1	67.10	2,939
Average	222.3	58.58	3,950
Std. Dev.	23.4	6.29	704

APPENDIX F

INDIVIDUAL SPECIMEN ±45° TENSION/INPLANE SHEAR PROPERTIES, BASELINE

The 36 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in inplane shear. A summary of these data was presented and discussed in Section 3.2.3.

TABLE F.1

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, -54°C (-65°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:				±45°
Material :	EA-9396 A/B; 7781 Glass			Batch #1	Task #6			Tested By:			PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T1	-65°F (DRY)	1.000	0.0699	2,842	40.68	2.956	20.34	1.058	0.397	8/17/89	(1,2,3,5)
BIL-GL-18-T7	"	1.001	0.0673	2,375	35.25	3.185	17.63	1.085	0.468	8/16/89	(1,2,3,5)
BIL-GL-18-T13	"	0.998	0.0665	1,964	29.59	3.267	14.80	1.140	0.433	"	(1,2,3,5)
BIL-GL-19-T4	"	0.999	0.0640	1,862	29.12	2.871	14.56	1.041	0.378	8/17/89	(1,2,3,5)
BIL-GL-19-T10	"	1.001	0.0710	1,857	26.13	2.779	13.06	0.981	0.417	"	(1,2,3,5)
BIL-GL-19(R)-T4	"	1.003	0.0640	2,075	32.32	3.573	16.16	1.289	0.386	"	(1,2,3,5)
BIL-GL-19(R)-T10	"	1.007	0.0720	2,920	40.29	2.633	20.15	0.912	0.444	8/16/89	(1,2,3,5)
				Average	33.34	3.038	16.67	1.072	0.418		
				Std. Dev.	5.64	0.323	2.82	0.120	0.033		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
280.5	20.38	140.2	7.294
243.1	21.96	121.5	7.480
204.1	22.52	102.0	7.858
200.8	19.79	100.4	7.179
180.2	19.16	90.1	6.761
222.9	24.63	111.4	8.888
277.8	18.15	138.9	6.286
Average 229.9	20.94	114.9	7.392
Std. Dev. 38.9	2.23	19.4	0.831

TABLE F.2

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, -54°C (-65°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:		±45°		
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #6		Tested By:		PM & DH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-X1	-65°F (DRY)	0.627	0.0616	1,395	36.12	2.818	18.06	1.031	0.366	3/15/90	(1,2,3,5)
BIL-GL-23(R)-X3	"	0.990	0.0636	1,759	27.93	2.547	13.97	0.904	0.408	"	(1,2,3,5)
BIL-GL-23(R)-X7	"	0.875	0.0635	1,831	32.97	2.561	16.48	0.901	0.421	"	(1,2,3,5)
BIL-GL-23(R)-16	"	0.999	0.0628	2,430	38.74	2.610	19.37	0.929	0.405	"	(1,2,3,5)
BIL-GL-20(R)-T4	"	0.996	0.0657	2,587	39.54	3.338	19.77	1.136	0.469	7/31/89	(1,2,3,5)
BIL-GL-20(R)-T10	"	0.997	0.0656	2,004	30.66	3.273	15.33	1.129	0.449	"	(1,2,3,5)
				Average	34.33	2.858	17.16	1.005	0.420		
				Std. Dev.	4.61	0.361	2.30	0.109	0.036		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
249.1	19.43	124.5	7.112
192.6	17.56	96.3	6.236
227.3	17.66	113.7	6.214
267.1	18.00	133.6	6.405
272.6	23.01	136.3	7.834
211.4	22.57	105.7	7.784
Average 236.7	19.70	118.3	6.931
Std. Dev. 31.8	2.49	15.9	0.755

TABLE F.3

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, -54°C (-65°F) DRY

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #6 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-24-T1	-65°F (DRY)	1.000	0.0662	2,246	33.93	2.970	16.96	1.064	0.396	8/17/89	(1,2,3,5)
BIL-GL-24-T7	"	1.000	0.0693	2,211	31.90	2.647	15.95	0.962	0.376	"	(1,2,3,5)
BIL-GL-24-T13	"	0.999	0.0705	1,945	27.61	2.762	13.81	0.975	0.416	"	(1,2,3,5)
BIL-GL-21-T4	"	0.996	0.0676	2,725	40.46	3.388	20.23	1.163	0.457	"	(1,2,3,5)
BIL-GL-21-T10	"	0.998	0.0703	2,374	33.84	2.458	16.92	0.917	0.341	8/18/89	(1,2,3,5)
				Average	33.55	2.845	16.77	1.016	0.397		
				Std. Dev.	4.64	0.356	2.32	0.098	0.043		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	233.9	20.48	117.0	7.337
	220.0	18.25	110.0	6.632
	190.4	19.04	95.2	6.724
	279.0	23.36	139.5	8.018
	233.3	16.95	116.7	6.320
Average	231.3	19.62	115.7	7.006
Std. Dev.	32.0	2.45	16.0	0.675

TABLE F.4

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:			±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #1	Task #6		Tested By:			TOB	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T2	72°F (DRY)	1.002	0.0675	1,828	27.03	2.565	13.52	0.880	0.457	8/11/89	(1,2,3,5)
BIL-GL-18-T8	"	1.000	0.0670	1,729	25.80	2.683	12.90	0.928	0.445	"	(1,2,3,5)
BIL-GL-18-T14	"	0.998	0.0663	1,525	23.06	2.390	11.53	0.836	0.429	"	(1,2,3,5)
BIL-GL-19-T5	"	0.995	0.0640	1,204	18.91	2.645	9.45	0.876	0.510	8/16/89	(1,2,3,5)
BIL-GL-19-T11	"	1.001	0.0650	1,371	21.07	2.212	10.54	0.765	0.446	"	(1,2,3,5)
BIL-GL-19(R)-T5	"	1.003	0.0640	1,366	21.28	2.515	10.64	0.878	0.432	"	(1,2,3,5)
BIL-GL-19(R)-T11	"	1.008	0.0720	1,565	21.56		10.78		0.425	"	(1,2,3,5,6)
				Average	22.67	2.502	11.34	0.861	0.449		
				Std. Dev.	2.85	0.176	1.43	0.055	0.029		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Incorrect load range; modulus calculations not included in averages.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
186.4	17.68	93.2	6.068
177.9	18.50	88.9	6.401
159.0	16.48	79.5	5.765
130.4	18.24	65.2	6.039
145.3	15.25	72.6	5.273
146.7	17.34	73.3	6.054
148.7		74.3	
Average 156.3	17.25	78.2	5.933
Std. Dev. 19.7	1.21	9.8	0.381

TABLE F.5

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test :	±45° Tension/inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #6		Tested By:	PM & DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-1	72°F (DRY)	0.994	0.0625	1,365	21.97	2.068	10.98	0.742	0.394	2/22/90	(1,2,3,5)
BIL-GL-23(R)-7	"	1.001	0.0651	1,537	23.59	2.208	11.79	0.746	0.480	"	(1,2,3,5)
BIL-GL-23(R)-13	"	1.001	0.0617	1,344	21.75	2.101	10.88	0.784	0.340	"	(1,2,3,5)
BIL-GL-23(R)-2	"	0.998	0.0648	1,415	21.88	1.829	10.94	0.664	0.377	"	(1,2,3,5)
BIL-GL-23(R)-8	"	1.001	0.0643	1,601	24.89	1.817	12.44	0.625	0.454	"	(1,2,3,5)
BIL-GL-23(R)-14	"	1.002	0.0623	1,396	22.38	2.268	11.19	0.817	0.388	"	(1,2,3,5)
BIL-GL-23(R)-3	"	0.999	0.0657	1,488	22.67	1.800	11.34	0.674	0.336	"	(1,2,3,5)
BIL-GL-23(R)-9	"	0.999	0.0642	1,542	24.06	1.953	12.03	0.652	0.498	"	(1,2,3,5)
BIL-GL-23(R)-15	"	1.000	0.0614	1,552	25.27	2.230	12.64	0.800	0.394	"	(1,2,3,5)
BIL-GL-20(R)-T5	"	0.995	0.0657	1,743	26.67	2.095	13.34	0.686	0.526	7/26/89	(1,2,3,5)
BIL-GL-20(R)-T1	"	0.996	0.0655	1,475	22.59	2.412	11.30	0.765	0.577	"	(1,2,3,5)
Average					23.43	2.071	11.71	0.723	0.433		
Std. Dev.					1.62	0.203	0.81	0.066	0.079		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
151.5	14.26	75.7	5.113
162.6	15.22	81.3	5.143
150.0	14.49	75.0	5.406
150.9	12.61	75.4	4.57
171.6	12.53	85.8	4.307
154.3	15.64	77.1	5.635
156.3	12.41	78.2	4.645
165.9	13.46	82.9	4.494
174.3	15.38	87.1	5.517
183.9	14.44	91.9	4.732
155.8	16.63	77.9	5.272
Average	161.5	14.28	80.8	4.986
Std. Dev.	11.2	1.40	5.6	0.453

TABLE F.6

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518								Fiber Orientation:	±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #6				Tested By:	TOB	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-24-T2	72° (DRY)	1.000	0.0685	1,628	23.77	2.215	11.89	0.772	0.435	8/11/89	(1,2,3,5)
BIL-GL-24-T8	"	.000	0.0696	1,434	20.60	1.972	10.30	0.705	0.398	"	(1,2,3,5)
BIL-GL-24-T14	"	0.999	0.0706	1,379	19.56	1.922	9.78	0.669	0.437	"	(1,2,3,5)
BIL-GL-21-T5	"	0.998	0.0686	1,584	23.12	2.137	11.56	0.747	0.431	"	(1,2,3,5)
BIL-GL-21-T11	"	0.997	0.0721	1,756	24.42	1.802	12.21	0.667	0.351	"	(1,2,3,5)
				Average	22.29	2.010	11.15	0.712	0.411		
				Std. Dev.	2.11	0.166	1.05	0.047	0.037		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
163.9	15.27	82.0	5.323
142.0	13.60	71.0	4.862
134.9	13.25	67.4	4.611
159.4	14.73	79.7	5.148
168.4	12.42	84.2	4.597
Average 153.7	13.86	76.9	4.908
Std. Dev. 14.5	1.15	7.3	0.323

TABLE F.7

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°		
Material :	EA-9396 A/B; 7781 Glass			Batch #1	Task #6			Tested By:	PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T3	200°F (DRY)	1.000	0.0671	1,218	18.15	1.406	9.08	0.392	0.794	8/18/89	(1,2,3,5)
BIL-GL-18-T9	"	1.000	0.0684	985	14.40	1.514	7.20	0.477	0.589	"	(1,2,3,5)
BIL-GL-18-T15	"	0.997	0.0677	1,012	14.99	1.698	7.50	0.505	0.681	"	(1,2,3,4)
BIL-GL-19-T6	"	1.000	0.0650	597	9.18	1.035	4.59	0.289	0.793	"	(1,2,3,5)
BIL-GL-19-T12	"	1.001	0.0650	898	13.80	1.591	6.90	0.499	0.594	"	(1,2,3,5)
BIL-GL-19(R)-T6	"	1.006	0.0690	935	13.47	1.578	6.73	0.485	0.628	"	(1,2,3,5)
BIL-GL-19(R)-T12	"	1.006	0.0710	1,061	14.85	1.567	7.43	0.474	0.652	"	(1,2,3,4)
				Average	14.12	1.484	7.06	0.446	0.676		
				Std. Dev.	2.66	0.217	1.33	0.079	0.087		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Incorrect load range; modulus calculations not included in averages.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
125.2	9.69	62.6	2.701
99.3	10.44	49.6	3.287
103.4	11.71	51.7	3.481
63.3	7.14	31.7	1.989
95.2	10.97	47.6	3.443
92.9	10.68	46.4	3.341
102.4	10.81	51.2	3.270
Average 97.4	10.23	48.7	3.073
Std. Dev. 18.4	1.49	9.2	0.544

TABLE F.8

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°		
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #6			Tested By:	PM & DH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-X2	200°F (DRY)	1.002	0.0635	865	13.60	1.463	6.80	0.512	0.429	3/15/90	(1,2,3,5)
BIL-GL-23(R)-X4	"	0.997	0.0641	779	12.18	1.246	6.09	0.413	0.508	"	(1,2,3,5)
BIL-GL-23(R)-X5	"	1.001	0.0616	747	12.12	1.301	6.06	0.418	0.555	"	(1,2,3,5)
BIL-GL-23(R)-X6	"	0.876	0.0637	820	14.71	1.459	7.35	0.451	0.617	"	(1,2,3,5)
BIL-GL-23(R)-7	"	1.022	0.0610	814	13.07	1.432	6.53	0.450	0.591	"	(1,2,3,5)
BIL-GL-20(R)-T6	"	0.994	0.0655	989	15.19	1.377	7.59	0.423	0.630	7/28/89	(1,2,3,5)
BIL-GL-20(R)-T12	"	0.999	0.0644	1,050	16.33	1.596	8.16	0.467	0.709	"	(1,2,3,5)
				Average	13.88	1.411	6.94	0.448	0.577		
				Std. Dev.	1.59	0.116	0.79	0.035	0.091		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
93.8	10.09	46.9	3.532
84.0	8.59	42.0	2.848
83.5	8.97	41.8	2.884
101.4	10.06	50.7	3.111
90.1	9.88	45.0	3.103
104.7	9.50	52.4	2.913
112.6	11.00	56.3	3.219
Average 95.7	9.73	47.9	3.087
Std. Dev. 10.9	0.80	5.5	0.239

TABLE F.9

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #6			Tested By:	PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-24-T3	200°F (DRY)	1.000	0.0689	1,106	16.06	1.777	8.03	0.549	0.619	8/21/89	(1,2,3,5)
BIL-GL-24-T9	"	1.001	0.0679	891	13.11	1.503	6.56	0.466	0.614	"	(1,2,3,5)
BIL-GL-24-T15	"	1.000	0.0655	895	13.67	1.479	6.83	0.433	0.710	"	(1,2,3,5)
BIL-GL-21-T6	"	0.998	0.0689	845	12.29	1.443	6.14	0.456	0.583	"	(1,2,3,5)
BIL-GL-21-T12	"	0.998	0.0699	1,334	19.11	1.785	9.56	0.547	0.631	"	(1,2,3,5)
				Average	14.85	1.597	7.42	0.490	0.631		
				Std. Dev.	2.77	0.169	1.38	0.054	0.047		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
110.7	12.25	55.4	3.785
90.4	10.36	45.2	3.210
94.2	10.20	47.1	2.982
84.7	9.95	42.4	3.142
131.8	12.31	65.9	3.772
Average 102.4	11.01	51.2	3.378
Std. Dev. 19.1	1.17	9.5	0.375

TABLE F.10

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, -54°C (-65°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #6			Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T4	-65°F (WET)	0.997	0.0670	1,071	16.03	2.806	8.02	0.924	0.519	1/18/90	(1,2,3,4,6,7)
BIL-GL-18-T10	"	0.999	0.0660	1,296	19.66	2.789	9.83	0.959	0.454	"	(1,2,3,4,6,7)
BIL-GL-19-T1	"	0.993	0.0650	1,375	21.31	2.793	10.66	0.933	0.496	"	(1,2,3,4,6,7)
BIL-GL-19-T7	"	1.000	0.0640	1,011	15.80	2.636	7.90	0.947	0.392	"	(1,2,3,5,6,7)
BIL-GL-19-T13	"	1.003	0.0660	1,404	21.21	2.752	10.61	0.969	0.421	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T1	"	1.003	0.0670	1,021	15.20	2.670	7.60	0.885	0.509	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T7	"	1.006	0.0730	1,084	14.75	2.568	7.38	0.870	0.476	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T13	"	1.006	0.0710	1,133	15.87	2.934	7.93	0.951	0.543	"	(1,2,3,4,6,7)
				Average	17.48	2.743	8.74	0.930	0.476		
				Std. Dev.	2.77	0.115	1.38	0.035	0.051		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 112 days.
(7) Weight gain = 1.9484%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
110.5	19.35	55.3	6.370
135.6	19.23	67.8	6.610
146.9	19.26	73.5	6.435
108.9	18.17	54.5	6.528
146.3	18.98	73.1	6.678
104.8	18.41	52.4	6.102
101.7	17.71	50.9	5.999
109.4	20.23	54.7	6.558
Average 120.5	18.92	60.3	6.407
Std. Dev. 19.1	0.79	9.5	0.377

TABLE F.11

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, -54°C (-65°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #2 — Task #6 — Tested By: PM & DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-4	-65°F (WET)	1.000	0.0644	1,179	18 31	2.403	9.15	0.867	0.385	4/5/90	(1,2,3,5,6,8)
BIL-GL-23(R)-10	"	1.002	0.0629	1,178	18.70	2.494	9.35	0.855	0.458	"	(1,2,3,4,6,8)
BIL-GL-20(R)-T1	"	0.997	0.0640	1,105	17.32	2.297	8.66	0.749	0.534	1/18/90	(1,2,3,4,6,7)
BIL-GL-20(R)-T7	"	0.995	0.0660	1,045	15.92	2.279	7.96	0.749	0.521	"	(1,2,3,4,6,7)
BIL-GL-20(R)-T13	"	0.996	0.0690	927	13.49	2.051	6.74	0.624	0.644	"	(1,2,3,4,6,7)
				Average	16.75	2.305	8.37	0.769	0.508		
				Std. Dev.	2.12	0.166	1.06	0.099	0.096		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
(7) Weight gain = 1.5524%
(8) Weight gain = 2.1134%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
126.2	16.57	63.1	5.981
128.9	17.19	64.5	5.897
119.5	15.84	59.7	5.163
109.8	15.71	54.9	5.167
93.0	14.14	46.5	4.301
Average 115.5	15.89	57.7	5.302
Std. Dev. 14.6	1.14	7.3	0.681

TABLE F.12

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, -54°C (-65°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-21-T1	-65°F (WET)	0.996	0.0660	1,203	18.29	2.954	9.15	0.976	0.514	1/18/90	(1,2,3,4,6,7)
BIL-GL-21-T7	"	0.997	0.0670	916	13.71	2.394	6.85	0.800	0.496	"	(1,2,3,4,6,7)
BIL-GL-21-T13	"	0.998	0.0680	1,187	17.48	2.822	8.74	0.965	0.463	"	(1,2,3,4,6,7)
BIL-GL-24-T4	"	0.998	0.0680	1,151	16.96	2.540	8.48	0.847	0.499	"	(1,2,3,4,6,8)
BIL-GL-24-T10	"	1.001	0.0670	1,115	16.62	2.350	8.31	0.774	0.519	"	(1,2,3,4,6,8)
				Average	16.61	2.612	8.31	0.872	0.498		
				Std. Dev.	1.74	0.266	0.87	0.093	0.022		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 112 days.
(7) Weight gain = 1.7099%
(8) Weight gain = 1.8162%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
126.1	20.37	63.1	6.727
94.5	16.51	47.3	5.517
120.6	19.46	60.3	6.653
116.9	17.52	58.5	5.842
114.6	16.21	57.3	5.335
Average 114.5	18.01	57.3	6.015
Std. Dev. 12.0	1.83	6.0	0.643

TABLE F.13

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:			±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #1	Task #6		Tested By:			DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T5	72°F (WET)	0.997	0.0670	792	11.86	1.643	5.93	0.478	0.720	1/16/90	(1,2,3,5,6,7)
BIL-GL-18-T11	"	1.000	0.0650	789	12.13	1.533	6.07	0.492	0.559	"	(1,2,3,5,6,7)
BIL-GL-19-T2	"	0.998	0.0660	753	11.43	1.318	5.72	0.438	0.504	"	(1,2,3,5,6,7)
BIL-GL-19-T8	"	1.000	0.0640	533	8.32	1.589	4.16	0.559	0.422	"	(1,2,3,5,6,7)
BIL-GL-19-T14	"	1.002	0.0680	759	11.14	1.558	5.57	0.436	0.788	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T2	"	1.004	0.0690	834	12.04	1.385	6.02	0.419	0.650	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T8	"	1.004	0.0720	634	8.77	1.450	4.38	0.467	0.552	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T14	"	1.007	0.0710	733	10.25	1.821	5.13	0.540	0.685	"	(1,2,3,4,6,7)
				Average	10.74	1.537	5.37	0.479	0.610		
				Std. Dev.	1.49	0.158	0.74	0.050	0.121		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
(7) Weight gain = 2.0141%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
81.8	11.33	40.9	3.293
83.6	10.57	41.8	3.390
78.8	9.08	39.4	3.020
57.4	10.96	28.7	3.851
76.8	10.74	38.4	3.005
83.0	9.55	41.5	2.892
60.5	10.00	30.2	3.221
70.7	12.55	35.3	3.726
Average 74.1	10.60	37.0	3.291
Std. Dev. 10.3	1.09	5.1	0.484

TABLE F.14

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #2	Task #6			Tested By:	PM & DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-5	72°F (WET)	0.998	0.0644	713	11.10	1.543	5.55	0.510	0.511	4/5/90	(1,2,3,5,6,8)
BIL-GL-23(R)-11	"	1.002	0.0626	714	11.39	1.575	5.70	0.564	0.397	"	(1,2,3,5,6,8)
BIL-GL-20(R)-T2	"	0.998	0.0720	730	10.17	1.279	5.08	0.363	0.761	1/16/90	(1,2,3,4,6,7)
BIL-GL-20(R)-T8	"	0.996	0.0650	660	10.20	1.121	5.10	0.336	0.668	"	(1,2,3,5,6,7)
BIL-GL-20(R)-T14	"	0.999	0.0680	818	12.05	1.461	6.02	0.429	0.703	"	(1,2,3,4,6,7)
				Average	10.98	1.396	5.49	0.441	0.608	
				Std. Dev.	0.81	0.192	0.40	0.096	0.150	

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
(7) Weight gain = 1.5177%
(8) Weight gain = 2.3245%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
76.6	10.64	38.3	3.519
78.5	10.86	39.3	3.887
70.1	8.82	35.0	2.503
70.3	7.73	35.2	2.318
83.1	10.08	41.5	2.959
Average 75.7	9.62	37.9	3.037
Std. Dev. 5.6	1.32	2.8	0.664

TABLE F.15

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:			±45°	
Material :	EA-9396 A/B; 7781 Glass			Batch #3	Task #6			Tested By:		DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-21-T2	72°F (WET)	0.993	0.0670	817	12.28	1.997	6.14	0.585	0.706	1/17/90	(1,2,3,4,6,7)
BIL-GL-21-T8	"	0.996	0.0650	588	9.09	1.653	4.54	0.541	0.529	"	(1,2,3,5,6,7)
BIL-GL-21-T14	"	0.996	0.0690	885	12.88	2.203	6.44	0.666	0.655	"	(1,2,3,5,6,7)
BIL-GL-24-T5	"	0.997	0.0670	810	12.12	1.629	6.06	0.535	0.524	"	(1,2,3,4,6,8)
BIL-GL-24-T11	"	0.998	0.0670	694	10.38	1.778	5.19	0.457	0.945	"	(1,2,3,4,6,8)
				Average	11.35	1.852	5.67	0.557	0.672		
				Std. Dev.	1.57	0.244	0.79	0.076	0.172		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
(7) Weight gain = 1.6932%
(8) Weight gain = 1.8157%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
84.7	13.77	42.3	4.035
62.7	11.40	31.3	3.729
88.8	15.19	44.4	4.589
83.6	11.23	41.8	3.686
71.5	12.26	35.8	3.151
Average 78.3	12.77	39.1	3.838
Std. Dev. 10.8	1.68	5.4	0.527

TABLE F.16

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #1 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-18-T6	200°F (WET)	0.999	0.0680	465	6.85	0.824	3.42	0.262	0.571	1/19/90	(1,2,3,5,6,7)
BIL-GL-18-T12	"	0.998	0.0650	360	5.55	0.724	2.78	0.206	0.758	"	(1,2,3,5,6,7)
BIL-GL-19-T3	"	0.999	0.0640	305	4.77	0.888	2.38	0.249	0.784	"	(1,2,3,5,6,7)
BIL-GL-19-T9	"	1.001	0.0650	286	4.39	0.967	2.20	0.319	0.514	"	(1,2,3,5,6,7)
BIL-GL-19-T15	"	1.003	0.0670	408	6.08	0.673	3.04	0.157	1.139	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T3	"	1.004	0.0690	413	5.96	0.667	2.98	0.164	1.039	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T9	"	1.003	0.0700	304	4.34	0.921	2.17	0.284	0.620	"	(1,2,3,4,6,7)
				Average	5.42	0.809	2.71	0.234	0.775		
				Std. Dev.	0.95	0.122	0.48	0.061	0.237		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 117 days.
(7) Weight gain = 2.0860%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
47.2	5.68	23.6	1.809
38.3	4.99	19.1	1.419
32.9	6.12	16.4	1.716
30.3	6.67	15.1	2.202
41.9	4.64	21.0	1.084
41.1	4.60	20.5	1.128
29.9	6.35	14.9	1.960
Average 37.4	5.58	18.7	1.571
Std. Dev. 6.6	0.84	3.3	0.341

TABLE F.17

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #2 — Task #6 — Tested By: PM & DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-23(R)-6	200°F (WET)	1.002	0.0643	377	5.86	0.739	2.93	0.208	0.778	4/5/90	(1,2,3,5,6,8)
BIL-GL-23(R)-12	"	1.000	0.0633	349	5.51	0.770	2.76	0.252	0.529	"	(1,2,3,5,6,8)
BIL-GL-20(R)-T3	"	0.996	0.0660	386	5.87	0.856	2.94	0.202	1.124	1/22/90	(1,2,3,5,6,7)
BIL-GL-20(R)-T9	"	0.993	0.0660	345	5.26	0.537	2.63	0.146	0.842	"	(1,2,3,5,6,7)
BIL-GL-20(R)-T15	"	1.000	0.0670	366	5.47	0.629	2.73	0.163	0.927	"	(1,2,3,5,6,7)
				Average	5.59	0.706	2.80	0.194	0.840		
				Std. Dev.	0.26	0.125	0.13	0.041	0.217		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 114 days.
(7) Weight gain = 1.5621%
(8) Weight gain = 1.9967%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
40.4	5.09	20.2	1.432
38.0	5.31	19.0	1.735
40.5	5.91	20.2	1.390
36.3	3.70	18.1	1.005
37.7	4.34	18.9	1.125
Average 38.6	4.87	19.3	1.338
Std Dev. 1.8	0.86	0.9	0.285

TABLE F.18

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass — Batch #3 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-21-T3	200°F (WET)	0.998	0.0680	371	5.46	1.175	2.73	0.309	0.898	1/22/90	(1,2,3,4,6,7)
BIL-GL-21-T9	"	0.998	0.0700	320	4.58	1.479	2.29	0.436	0.695	"	(1,2,3,5,6,7)
BIL-GL-21-T15	"	0.996	0.0660	432	6.57	1.268	3.29	0.363	0.746	"	(1,2,3,4,6,7)
BIL-GL-24-T6	"	0.999	0.0670	360	5.37	0.673	2.69	0.183	0.842	"	(1,2,3,5,6,8)
BIL-GL-24-T12	"	0.998	0.0690	348	5.05	0.860	2.53	0.215	0.996	"	(1,2,3,5,6,8)
				Average	5.41	1.091	2.70	0.301	0.835		
				Std. Dev.	0.74	0.323	0.37	0.104	0.120		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 114 days.
(7) Weight gain = 1.7197%
(8) Weight gain = 1.8613%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
37.7	8.10	18.8	2.134
31.6	10.19	15.8	3.006
45.3	8.74	22.7	2.504
37.0	4.64	18.5	1.260
34.8	5.93	17.4	1.485
Average 37.3	7.52	18.6	2.078
Std. Dev. 5.1	2.22	2.5	0.719

TABLE F.19

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 1, -54°C (-65°F) DRY

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; W133 Graphite — Batch #1 — Task #6 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-1	-65°F (DRY)	1.003	0.1163	5,090	43.62	3.222	21.81	0.967	0.666	12/29/89	(1,2,3,5)
BIL-GR-37-7	"	1.002	0.1236	4,778	38.56	2.718	19.28	0.776	0.751	"	(1,2,3,5)
BIL-GR-37-13	"	1.001	0.1223	4,248	34.69	2.744	17.35	0.766	0.792	"	(1,2,3,5)
BIL-GR-42-T4	"	0.996	0.1212	4,011	33.22	2.544	16.61	0.758	0.679	1/2/90	(1,2,3,5)
BIL-GR-42-T10	"	0.999	0.1229	3,848	31.34	2.482	15.67	0.719	0.726	"	(1,2,3,5)
				Average	36.29	2.742	18.14	0.797	0.723		
				Std. Dev.	4.88	0.290	2.44	0.097	0.052		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	300.8	22.21	150.4	6.667
	265.9	18.74	132.9	5.350
	239.2	18.92	119.6	5.279
	229.0	17.54	114.5	5.224
	216.1	17.11	108.1	4.959
Average	250.2	18.90	125.1	5.496
Std. Dev.	33.7	2.00	16.8	0.671

TABLE F.20

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, -54°C (-65°F) DRY

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; W133 Graphite — Batch #2 — Task #6 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-1	-65°F (DRY)	1.003	0.1220	4,167	34.05	2.673	17.03	0.819	0.632	1/2/90	(1,2,3,5)
BIL-GR-38-7	"	1.002	0.1243	4,797	38.50	3.204	19.25	0.940	0.704	"	(1,2,3,5)
BIL-GR-38-13	"	1.002	0.1245	4,063	32.58	2.972	16.29	0.898	0.656	"	(1,2,3,5)
BIL-GR-39-4	"	0.996	0.1220	4,456	36.67	2.559	18.33	0.772	0.659	"	(1,2,3,5)
BIL-GR-39-10	"	0.997	0.1220	4,014	33.00	2.647	16.50	0.769	0.722	"	(1,2,3,5)
				Average	34.96	2.811	17.48	0.839	0.674		
				Std. Dev.	2.54	0.269	1.27	0.077	0.037		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	234.8	18.43	117.4	5.649
	265.5	22.09	132.7	6.482
	224.7	20.49	112.3	6.188
	252.8	17.65	126.4	5.320
	227.6	18.25	113.8	5.301
Average	241.1	19.38	120.5	5.788
Std. Dev.	17.5	1.85	8.8	0.529

TABLE F.21

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 3, -54°C (-65°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #6		Tested By:	PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-1	-65°F (DRY)	0.998	0.1187	4,697	39.64	3.122	19.82	0.874	0.787	1/2/90	(1,2,3,5)
BIL-GR-40-7	"	1.001	0.1305	4,951	37.89	2.588	18.95	0.769	0.682	"	(1,2,3,5)
BIL-GR-40-13	"	1.002	0.1283	5,098	39.65	2.889	19.83	0.834	0.733	1/3/90	(1,2,3,5)
BIL-GR-41-T4	"	1.000	0.1202	4,878	40.50	3.180	20.30	0.890	0.787	"	(1,2,3,5)
BIL-GR-41-T10	"	0.998	0.1195	4,504	37.75	2.943	18.88	0.882	0.668	"	(1,2,3,5)
				Average	39.11	2.945	19.55	0.850	0.731		
				Std. Dev.	1.24	0.233	0.62	0.050	0.056		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
273.3	21.53	136.6	6.024
261.3	17.85	130.6	5.305
273.4	19.92	136.7	5.749
280.0	21.93	140.0	6.134
260.3	20.29	130.2	6.083
Average 269.6	20.30	134.8	5.859
Std. Dev. 8.5	1.61	4.3	0.344

TABLE F.22

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #6		Tested By:	PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-2	72°F (DRY)	1.002	0.1201	3,599	29.91	2.582	14.95	0.721	0.790	12/11/89	(1,2,3,5)
BIL-GR-37-8	"	1.004	0.1236	3,413	27.50	1.937	13.75	0.535	0.810	"	(1,2,3,5)
BIL-GR-37-14	"	1.003	0.1227	3,125	25.39	2.107	12.69	0.560	0.881	"	(1,2,3,5)
BIL-GR-42-T5	"	0.992	0.1238	2,883	23.49	1.979	11.74	0.568	0.742	"	(1,2,3,5)
BIL-GR-42-T11	"	0.998	0.1238	2,864	23.17	1.766	11.59	0.510	0.733	"	(1,2,3,5)
				Average	25.89	2.074	12.95	0.579	0.791		
				Std. Dev.	2.83	0.309	1.42	0.083	0.060		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
206.2	17.81	103.1	4.974
189.6	13.35	94.8	3.689
175.1	14.53	87.5	3.861
162.0	13.64	81.0	3.916
159.8	12.18	79.9	3.513
Average 178.5	14.30	89.3	3.991
Std. Dev. 19.5	2.13	9.8	0.572

TABLE F.23

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test :	±45° Tension/Inplane Shear: ASTM-D3518						Fiber Orientation:	±45°			
Material :	E[illegible]-9396 A/B; W133 Graphite			Batch #2	Task #6		Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	*Ultimate* Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	*In-Plane* Shear Strength (Ksi.)	*In-Plane* Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-2	72°F (DRY)	1.002	0.1213	3,064	25.20	2.208	12.60	0.657	0.679	11/27/89	(1,2,3,5)
BIL-GR-38-8	"	1.004	0.1241	2,939	23.58	2.186	11.79	0.676	0.618	"	(1,2,3,5)
BIL-GR-38-14	"	0.999	0.1229	2,803	22.84	2.275	11.42	0.668	0.702	"	(1,2,3,5)
BIL-GR-39-5	"	0.990	0.1231	2,958	24.27	1.929	12.13	0.550	0.753	"	(1,2,3,5)
BIL-GR-39-11	"	0.990	0.1236	2,804	22.91	2.041	11.46	0.551	0.851	"	(1,2,3,5)
				Average	23.76	2.128	11.88	0.621	0.721		
				Std. Dev.	0.99	0.140	0.50	0.064	0.087		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
173.7	15.23	86.9	4.533
162.6	15.07	81.3	4.658
157.5	15.69	78.7	4.608
167.3	13.30	83.7	3.794
158.0	14.07	79.0	3.802
Average 163.8	14.67	81.9	4.279
Std. Dev. 6.8	0.97	3.4	0.441

TABLE F.24

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #6		Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-2	72°F (DRY)	0.999	0.1203	3,696	30.75	2.402	15.37	0.673	0.783	11/27/89	(1,2,3,5)
BIL-GR-40-8	"	1.001	0.1312	3,229	24.60	1.984	12.30	0.568	0.747	"	(1,2,3,5)
BIL-GR-40-14	"	1.001	0.1242	3,390	27.26	2.232	13.63	0.626	0.783	"	(1,2,3,5)
BIL-GR-41-5	"	1.000	0.1213	3,435	28.32	2.423	14.16	0.659	0.840	"	(1,2,3,5)
BIL-GR-41-11	"	0.997	0.1208	3,051	25.32	2.012	12.66	0.685	0.468	"	(1,2,3,5)
				Average	27.25	2.211	13.62	0.642	0.724		
				Std. Dev.	2.46	0.208	1.23	0.047	0.147		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
212.0	16.56	106.0	4.642
169.6	13.68	84.8	3.916
187.9	15.39	94.0	4.318
195.2	16.71	97.6	4.540
174.6	13.88	87.3	4.725
Average 187.9	15.24	93.9	4.428
Std. Dev. 16.9	1.43	8.5	0.325

TABLE F.25

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #6		Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-3	200°F (DRY)	1.004	0.1242	2,319	18.60	1.654	9.30	0.433	0.908	1/3/90	(1,2,3,5)
BIL-GR-37-9	"	1.005	0.1241	2,122	17.01	1.380	8.50	0.357	0.933	"	(1,2,3,5)
BIL-GR-37-15	"	1.005	0.1231	1,718	13.88	1.423	6.94	0.365	0.951	"	(1,2,3,5)
BIL-GR-42-T6	"	0.998	0.1233	1,710	13.90	1.381	6.95	0.378	0.827	"	(1,2,3,5)
BIL-GR-42-T12	"	0.997	0.1231	1,747	14.23	1.356	7.12	0.366	0.851	"	(1,2,3,5)
				Average	15.52	1.439	7.76	0.380	0.894		
				Std. Dev.	2.16	0.122	1.08	0.031	0.053		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
128.2	11.40	64.1	2.988
117.3	9.51	58.6	2.461
95.7	9.81	47.9	2.514
95.8	9.52	47.9	2.606
98.1	9.35	49.1	2.526
Average 107.0	9.92	53.5	2.619
Std. Dev. 14.9	0.84	7.4	0.213

TABLE F.26

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	*EA-9396 A/B; W133 Graphite*			*Batch #2*	*Task #6*		Tested By:	*DH*			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-3	200°F (DRY)	0.999	0.1205	2,065	17.16	1.945	8.58	0.546	0.780	1/5/90	(1,2,3,5)
BIL-GR-38-9	"	1.004	0.1228	1,812	14.70	1.667	7.35	0.477	0.747	"	(1,2,3,5)
BIL-GR-38-15	"	0.998	0.1207	1,747	14.50	1.887	7.25	0.561	0.683	"	(1,2,3,5)
BIL-GR-39-6	"	0.998	0.1222	1,816	14.89	1.406	7.45	0.372	0.891	"	(1,2,3,5)
BIL-GR-39-12	"	0.990	0.1226	1,831	15.09	1.318	7.54	0.347	0.896	"	(1,2,3,5)
				Average	15.27	1.645	7.63	0.461	0.799		
				Std. Dev.	1.08	0.280	0.54	0.098	0.093		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
118.3	13.41	59.2	3.768
101.3	11.49	50.7	3.290
100.0	13.01	50.0	3.866
102.7	9.70	51.3	2.563
104.0	9.08	52.0	2.396
Average 105.3	11.34	52.6	3.176
Std. Dev. 7.4	1.93	3.7	0.675

TABLE F.27

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) DRY

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°	
Material :	EA-9396 A/B; W133 Graphite			Batch #3	Task #6			Tested By:	DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-3	200°F (DRY)	1.002	0.1208	2,041	16.86	1.640	8.43	0.449	0 824	1/5/90	(1,2,3,5)
BIL-GR-40-9	"	1.004	0.1296	1,897	14.58	1.386	7.29	0.377	0.835	"	(1,2,3,5)
BIL-GR-40-15	"	1.005	0.1225	2,014	16.37	1.475	8.18	0.399	0.851	"	(1,2,3,5)
BIL-GR-41-6	"	0.998	0.1218	2,133	17.54	1.603	8.77	0.409	0.960	"	(1,2,3,5)
BIL-GR-41-12	"	0.999	0.1212	1,846	15.24	1.236	7.62	0.357	0.732	"	(1,2,3,5)
				Average	16.12	1.468	8.06	0.398	0.840		
				Std. Dev.	1.20	0.164	0.60	0.035	0.081		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
116.3	11.30	58.1	3.098
100.6	9.55	50.3	2.603
112.9	10.17	56.4	2.748
120.9	11.05	60.5	2.819
105.1	8.52	52.5	2.461
Average 111.1	10.12	55.6	2.746
Std. Dev. 8.3	1.13	4.1	0.241

TABLE F.28

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, -54°C (-65°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #6		Tested By:	PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-4	-65°F (WET)	1.004	0.1236	5,164	41.60	3.246	20.80	0.894	0.816	2/16/90	(1,2,3,5,6,7)
BIL-GR-37-10	"	1.003	0.1233	3,779	30.55	2.985	15.27	0.881	0.694	"	(1,2,3,5,6,7)
BIL-GR-42-T1	"	0.985	0.1121	3,278	29.69	2.825	14.84	0.879	0.606	"	(1,2,3,5,6,8)
BIL-GR-42-T7	"	0.997	0.1221	3,746	30.76	2.633	15.38	0.834	0.578	"	(1,2,3,5,6,8)
BIL-GR-42-T13	"	0.997	0.1216	3,690	30.44	2.795	15.22	0.837	0.671	"	(1,2,3,5,6,8)
				Average	32.61	2.897	16.30	0.865	0.673		
				Std. Dev.	5.04	0.232	2.52	0.028	0.093		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight gain = 2.1103%
(8) Weight gain = 2.1150%

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	286.8	22.38	143.4	6.163
	210.6	20.58	105.3	6.074
	204.7	19.48	102.3	6.063
	212.1	18.16	106.1	5.754
	209.9	19.27	105.0	5.768
Average	224.8	19.97	112.4	5.964
Std. Dev.	34.8	1.60	17.4	0.190

TABLE F.29

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 2, -54°C (-65°F) WET

Test :	±45° Tension/Inplane Shear; ASTM-D3518							Fiber Orientation:	±45°		
Material :	EA-9396 A/B; W133 Graphite			Batch #2	Task #6			Tested By:	PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (los.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-4	-65°F (WET)	1.001	0.1227	4,800	39.09	3.685	19.54	1.080	0.706	2/20/90	(1,2,3,5,6,7)
BIL-GR-38-10	"	0.982	0.1226	3,977	33.04	3.295	16.52	1.015	0.623	"	(1,2,3,5,6,7)
BIL-GR-39-1	"	0.996	0.1119	3,567	32.01	2.998	16.01	0.867	0.729	"	(1,2,3,5,6,8)
BIL-GR-39-7	"	0.996	0.1247	4,032	32.46	2.663	16.23	0.794	0.677	"	(1,2,3,5,6,8)
BIL-GR-39-13	"	0.996	0.1227	3,878	31.74	2.774	15.87	0.862	0.609	"	(1,2,3,5,6,8)
				Average	33.67	3.083	16.83	0.924	0.669		
				Std. Dev.	3.07	0.414	1.54	0.119	0.052		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight gain = 2.0754%
(8) Weight gain = 2.3377%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
269.5	25.41	134.8	7.449
227.8	22.72	113.9	6.997
220.7	20.67	110.4	5.980
223.8	18.36	111.9	5.474
218.8	19.12	109.4	5.945
Average 232.1	21.26	116.1	6.369
Std. Dev. 21.2	2.86	10.6	0.820

TABLE F.30

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, -54°C (-65°F) WET

Test	±45° Tension/Inplane Shear: ASTM-D3518						Fiber Orientation:	±45°			
Material	EA-9396 A/B; W133 Graphite		Batch #3	Task #6			Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-4	-65°F (WET)	1.002	0.1233	4,675	37.84	2.790	18.92	0.761	0.834	2/16/90	(1,2,3,5,6,7)
BIL-GR-40-10	"	1.000	0.1327	3,647	27.50	2.116	13.75	0.623	0.698	"	(1,2,3,5,6,7)
BIL-GR-41-1	"	0.989	0.1152	4,202	36.86	2.594	18.43	0.714	0.816	"	(1,2,3,5,6,8)
BIL-GR-41-7	"	0.999	0.1220	4,521	37.11	2.696	18.55	0.775	0.740	"	(1,2,3,5,6,8)
BIL-GR-41-13	"	0.998	0.1182	3,955	33.53	2.509	16.77	0.672	0.868	"	(1,2,3,5,6,8)
				Average	34.57	2.541	17.28	.709	0.791		
				Std. Dev.	4.29	0.260	2.14	.063	0.070		

Remarks.

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight gain = 2.0838%
(8) Weight gain = 2.1628%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
260.9	19.23	130.5	5.244
189.6	14.59	94.8	4.296
254.2	17.88	127.1	4.924
255.8	18.59	127.9	5.343
231.2	17.30	115.6	4.631
Average 238.4	17.52	119.2	4.888
Std. Dev. 29.6	1.79	14.8	0.433

TABLE F.31

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test: ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material: EA-9396 A/B; W133 Graphite — Batch #1 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-5	72°F (WET)	1.004	0.1232	3,014	24.37	1.789	12.19	0.477	0.876	2/16/90	(1,2,3,5,6,7)
BIL-GR-37-11	"	1.003	0.1232	2,504	20.26	1.920	10.13	0.563	0.706	"	(1,2,3,5,6,7)
BIL-GR-42-T2	"	0.996	0.1168	2,264	19.46	1.697	9.73	0.508	0.670	"	(1,2,3,5,6,8)
BIL-GR-42-T8	"	1.000	0.1245	2,188	17.57	1.530	8.79	0.452	0.692	"	(1,2,3,5,6,8)
BIL-GR-42-T14	"	0.998	0.1219	2,196	18.05	1.573	9.02	0.462	0.702	"	(1,2,3,5,6,8)
				Average	19.94	1.702	9.97	0.492	0.729		
				Std. Dev.	2.70	0.159	1.35	0.045	0.083		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached
(3) Test speed = 0.1 in/min
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
(7) Weight gain = 2.1103%
(8) Weight gain = 2.1150%

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	168.1	12.34	84.0	3.288
	139.7	13.24	69.8	3.879
	134.2	11.70	67.1	3.502
	121.1	10.55	60.6	3.118
	124.4	10.84	62.2	3.186
Average	137.5	11.73	68.7	3.395
Std. Dev.	18.6	1.10	9.3	0.307

TABLE F.32

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B: W133 Graphite — Batch #2 — Task #6 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-5	72°F (WET)	0.993	0.1218	3,062	25.30	2.818	12.65	0.757	0.861	2/15/90	(1,2,3,5,6,7)
BIL-GR-38-11	"	0.990	0.1208	2,283	19.09	2.428	9.54	0.744	0.631	"	(1,2,3,5,6,7)
BIL-GR-39-2	"	0.993	0.1159	2,175	18.90	1.998	9.45	0.512	0.951	"	(1,2,3,5,6,8)
BIL-GR-39-8	"	0.996	0.1243	2,476	20.00	1.853	10.00	0.526	0.762	"	(1,2,3,5,6,8)
BIL-GR-39-14	"	0.995	0.1228	2,324	19.03	1.719	9.51	0.508	0.691	"	(1,2,3,5,6,8)
				Average	20.46	2.163	10.23	0.610	0.779		
				Std. Dev.	2.74	0.453	1.37	0.129	0.126		

Remarks

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
(7) Weight gain = 2.0754%
(8) Weight gain = 2.3377%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
174.5	19.43	87.2	5.221
131.6	16.74	65.8	5.132
130.3	13.78	65.2	3.531
137.9	12.78	69.0	3.626
131.2	11.85	65.6	3.504
Average	141.1	14.92	70.6	4.203
Std. Dev.	18.9	3.12	9.4	0.891

TABLE F.33

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test	±45° Tension/inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material	EA-9396 A/B; W133 Graphite			Batch #3	Task #6		Tested By:	PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-5	72°F (WET)	1.002	0.1264	2,921	23.07	1.785	11.53	0.471	0.894	2/16/90	(1,2,3,5,6,7)
BIL-GR-40-11	"	1.003	0.1311	2,617	19.90	1.788	9.95	0.514	0.738	"	(1,2,3,5,6,7)
BIL-GR-41-T2	"	0.996	0.1188	2,943	24.88	2.103	12.44	0.550	0.912	"	(1,2,3,5,6,8)
BIL-GR-41-T8	"	0.998	0.1210	2,772	22.97	2.193	11.48	0.613	0.788	"	(1,2,3,5,6,8)
BIL-GR-41-T14	"	0.997	0.1181	2,474	21.01	1.888	10.51	0.469	1.014	"	(1,2,3,5,6,8)
				Average	22.37	1.952	11.18	0.524	0.869		
				Std. Dev.	1.94	0.187	0.97	0.060	0.108		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
(7) Weight gain = 2.0838%
(8) Weight gain = 2.1628%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
159.1	12.31	79.5	3.249
137.2	12.33	68.6	3.547
171.6	14.50	85.8	3.792
158.4	15.12	79.2	4.230
144.9	13.02	72.4	3.233
Average 154.2	13.46	77.1	3.610
Std. Dev. 13.4	1.29	6.7	0.416

TABLE F.34

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; W133 Graphite — Batch #1 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-37-6	200°F (WET)	1.001	0.1230	1,343	10.91	0.784	5.46	0.201	0.954	2/20/90	(1,2,3,5,6,7,9)
BIL-GR-37-12	"	1.002	0.1238	1,179	9.51	1.168	4.75	0.330	0.772	"	(1,2,3,5,6,7,9)
BIL-GR-42-T3	"	0.998	0.1194	1,069	8.97	0.985	4.49	0.290	0.696	"	(1,2,3,5,6,8,9)
BIL-GR-42-T9	"	0.990	0.1240	1,008	8.21	0.694	4.11	0.200	0.732	"	(1,2,3,5,6,8,9)
BIL-GR-42-T15	"	1.000	0.1107	846	7.64	0.699	3.82	0.216	0.621	"	(1,2,3,5,6,8,9)
				Average	9.05	0.866	4.52	0.247	0.755		
				Std. Dev.	1.26	0.206	0.63	0.059	0.124		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight gain = 2.1103%
(8) Weight gain = 2.1150%
(9) These specimens were supposed to have been tested at the 200°F(Wet) condition. They were inadvertently tested at 72°(Wet).

SI Conversion

	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
	75.2	5.41	37.6	1.383
	65.6	8.05	32.8	2.272
	61.9	6.79	30.9	2.002
	56.6	4.78	28.3	1.380
	52.7	4.82	26.3	1.487
Average	62.4	5.97	31.2	1.705
Std. Dev.	8.7	1.42	4.4	0.408

TABLE F.35

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; W133 Graphite — Batch #2 — Task #6 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-38-6	200°F (WET)	1.001	0.1226	1,315	10.71	1.276	5.36	0.303	1.106	2/20/90	(1,2,3,5,6,7,9)
BIL-GR-38-12	"	0.999	0.1245	1,053	8.47	1.560	4.23	0.468	0.666	"	(1,2,3,5,6,7,9)
BIL-GR-39-3	"	0.996	0.1194	1,011	8.50	0.775	4.25	0.198	0.961	"	(1,2,3,5,6,8,9)
BIL-GR-39-9	"	0.999	0.1244	1,034	8.31	0.740	4.16	0.218	0.699	"	(1,2,3,5,6,8,9)
BIL-GR-39-15	"	0.996	0.1184	1,025	8.70	0.592	4.35	0.153	0.934	"	(1,2,3,5,6,8,9)
				Average	8.94	0.989	4.47	0.268	0.873		
				Std. Dev.	1.00	0.410	0.50	0.124	0.186		

Remarks:

(1) The in-plane shear modulus is calculated using the relation [G=E/2(1+v)].

(2) Specimens had 0° and 90° strain gages bonded.

Test rate = 0.1 in/min.

Specimen failed inside the "tab area".

(3) Specimen failed within the 6.5 inch gage section.

(6) Specimens conditioned @ 140°F/95-100% R.H. to saturation.

(7) Weight gain = 2.0754%

(8) Weight gain = 2.3377%

(9) These specimens were supposed to have been tested at the 200°F(Wet) condition. They were inadvertently tested at 72°(Wet).

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
73.9	8.80	36.9	2.088
58.4	10.75	29.2	3.227
58.6	5.34	29.3	1.363
57.3	5.10	28.7	1.502
60.0	4.08	30.0	1.055
Average 61.6	6.82	30.8	1.847
Std. Dev. 6.9	2.83	3.5	0.858

TABLE F.36

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B: W133 Graphite — Batch #3 — Task #6 — Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-40-6	200°F (WET)	1.003	0.1284	1,213	9.42	0.848	4.71	0.209	1.029	2/20/90	(1,2,3,5,6,7)
BIL-GR-40-12	"	1.003	0.1297	1,139	8.75	1.048	4.38	0.266	0.969	"	(1,2,3,5,6,7)
BIL-GR-41-T3	"	0.996	0.1202	1,234	10.31	1.030	5.15			"	(1,2,3,5,6,8,9)
BIL-GR-41-T9	"	0.979	0.1196	999	8.53	1.054	4.26	0.262	1.015	"	(1,2,3,5,6,8)
BIL-GR-41-T15	"	1.000	0.1213	941	7.76	0.803	3.88	0.176	1.284	"	(1,2,3,5,6,8)
				Average	8.95	0.956	4.48	0.228	1.074		
				Std. Dev.	0.96	0.121	0.48	0.043	0.142		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
(7) Weight gain = 2.0838%
(8) Weight gain = 2.1628%
(9) 90° strain gage failed.

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
65.0	5.84	32.5	1.440
60.4	7.22	30.2	1.835
71.1	7.10	35.5	3.551
58.8	7.27	29.4	1.804
53.5	5.53	26.8	1.211
Average	61.7	6.59	30.9	1.968
Std. Dev.	6.6	0.84	3.3	0.922

APPENDIX G
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR PROPERTIES, BASELINE

The 18 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in interlaminar shear. A summary of these data was presented and discussed in Section 3.2.4.

TABLE G.1

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #1 Task #7 Tested By: TOB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-13(R)-3	72°F (DRY)	1.001	0.1357	1.063	1,040	5.742	4/14/89	
BIL-GL-13(R)-11	"	0.999	0.1371	1.063	1,066	5.839	"	
BIL-GL-13(R)-24	"	1.001	0.1359	1.063	1,120	6.174	"	
BIL-GL-13(R)-33	"	1.002	0.1341	1.063	1,036	5.786	"	
BIL-GL-13(R)-53	"	1.001	0.1336	1.063	980	5.493	"	
					Average	5.806		
					Std. Dev.	0.244		

SI Conversion

Ultimate Shear Strength (MPa)
39.59
40.26
42.57
39.89
37.87
Average 40.04
Std. Dev. 1.69

TABLE G.2

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #2 Task #7 Tested By: TOB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-11-1	72°F (DRY)	0.998	0.1309	1.063	926	5.316	4/14/89	
BIL-GL-11-4	"	1.001	0.1312	1.063	969	5.530	"	
BIL-GL-11-7	"	0.992	0.1316	1.063	1,012	5.816	"	
BIL-GL-11-10	"	1.002	0.1315	1.063	974	5.543	"	
BIL-GL-11-13	"	1.000	0.1345	1.063	996	5.549	"	
					Average	5.551		
					Std. Dev.	0.177		

SI Conversion
Ultimate Shear Strength (MPa)
36.66
38.13
40.10
38.22
38.26
Average 38.27
Std. Dev. 1.22

TABLE G.3

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #3 Task #7 Tested By: TOB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-12-1	72°F (DRY)	0.996	0.1281	1.063	922	5.419	4/14/89	
BIL-GL-12-4	"	1.000	0.1332	1.063	1,017	5.729	"	
BIL-GL-12-7	"	1.001	0.1304	1.063	958	5.508	"	
BIL-GL-12-10	"	1.003	0.1313	1.063	905	5.156	"	
BIL-GL-12-13	"	1.001	0.1342	1.063	1,025	5.721	"	
					Average	5.507		
					Std. Dev.	0.238		

SI Conversion
Ultimate Shear Strength (MPa)
37.37
39.50
37.98
35.55
39.45
Average 37.97
Std. Dev. 1.64

TABLE G.4

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #1 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-13(R)-4	72°F (WET)	1.001	0.1353	1.0804	482	2.669	10/30/89	(1,2)
BIL-GL-13(R)-12	"	0.999	0.1344	1.0804	477	2.663	"	(1,2)
BIL-GL-13(R)-25	"	1.001	0.1369	1.0804	510	2.793	"	(1,2)
BIL-GL-13(R)-34	"	1.000	0.1352	1.0804	489	2.714	"	(1,2)
BIL-GL-13(R)-54	"	1.000	0.1320	1.0804	473	2.690	"	(1,2)
					Average	2.706		
					Std. Dev.	0.053		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.32%

SI Conversion
Ultimate Shear Strength (MPa)
18.40
18.36
19.26
18.71
18.55
Average 18.66
Std. Dev. 0.36

TABLE G.5

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #2 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-11-2	72°F (WET)	0.998	0.1318	1.063	511	2.912	10/27/89	(1,2)
BIL-GL-11-5	"	0.998	0.1325	1.063	533	3.019	"	(1,2)
BIL-GL-11-8	"	0.991	0.1315	1.063	499	2.874	"	(1,2)
BIL-GL-11-11	"	1.006	0.1337	1.063	547	3.049	"	(1,2)
BIL-GL-11-14	"	1.001	0.1346	1.063	573	3.188	"	(1,2)
					Average	3.008		
					Std. Dev.	0.124		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.10%

SI Conversion
Ultimate Shear Strength (MPa)
20.08
20.82
19.81
21.02
21.98
Average 20.74
Std. Dev. 0.85

TABLE G.6

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)					Specimen Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass	Batch #3	Task #7				Tested By:	DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-12-2	72°F (WET)	1.000	0.1324	1.066	572	3.244	10/27/89	(1,2)
BIL-GL-12-5	"	1.000	0.1340	1.066	562	3.148	"	(1,2)
BIL-GL-12-8	"	1.000	0.1318	1.066	559	3.180	"	(1,2)
BIL-GL-12-11	"	0.999	0.1319	1.066	569	3.240	"	(1,2)
BIL-GL-12-14	"	1.006	0.1355	1.066	594	3.271	"	(1,2)
					Average	3.216		
					Std. Dev.	0.051		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.09%

SI Conversion
Ultimate Shear Strength (MPa)
22.36
21.70
21.92
22.34
22.55
Average 22.18
Std. Dev. 0.35

TABLE G.7

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #1 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-13(R)-5	200°F (WET)	1.001	0.1369	1.080	230	1.258	10/30/89	(1,2)
BIL-GL-13(R)-13	"	1.002	0.1349	1.080	229	1.272	"	(1,2)
BIL-GL-13(R)-26	"	1.002	0.1350	1.080	247	1.369	"	(1,2)
BIL-GL-13(R)-35	"	1.001	0.1346	1.080	249	1.388	"	(1,2)
BIL-GL-13(R)-55	"	1.002	0.1353	1.080	257	1.421	"	(1,2)
					Average	1.342		
					Std. Dev.	0.073		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.24%

SI Conversion
Ultimate Shear Strength (MPa)
8 67
8.77
9.44
9.57
9.80
Average 9.25
Std. Dev. 0.50

TABLE G.8

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : Apparent Interlaminar Shear, ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; 7781 Glass Batch #2 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-11-3	200°F (WET)	1.002	0.1312	1.063	349	1.989	10/27/89	(1,2)
BIL-GL-11-6	"	0.999	0.1324	1.063	329	1.865	"	(1,2)
BIL-GL-11-9	"	1.001	0.1291	1.063	313	1.817	"	(1,2)
BIL-GL-11-12	"	1.002	0.1359	1.063	351	1.931	"	(1,2)
BIL-GL-11-15	"	0.995	0.1357	1.063	362	2.011	"	(1,2)
					Average	1.922		
					Std. Dev.	0.082		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.09%

SI Conversion
Ultimate Shear Strength (MPa)
13.71
12.86
12.53
13.32
13.86
Average 13.26
Std. Dev. 0.56

TABLE G.9

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344			(4pt loading at 1/4 pts. L/D = 8/1)				Specimen Orientation: Warp	
Material : EA-9396 A/B; 7781 Glass			Batch #3	Task #7			Tested By:	DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-12-3	200°F (WET)	1.002	0.1331	1.066	336	1.887	10/27/89	(1,2)
BIL-GL-12-6	"	1.003	0.1335	1.066	349	1.952	"	(1,2)
BIL-GL-12-9	"	1.002	0.1329	1.066	313	1.765	"	(1,2)
BIL-GL-12-12	"	1.001	0.1333	1.066	328	1.840	"	(1,2)
BIL-GL-12-15	"	1.001	0.1337	1.066	345	1.930	"	(1,2)
					Average	1.875		
					Std. Dev.	0.075		

Remarks:

(1) Specimens aged @ 140°F/95–100% R.H. to saturation.

(2) Average weight gain = 2.11%

SI Conversion
Ultimate Shear Strength (MPa)
13.01
13.46
12.17
12.69
13.31
Average 12.93
Std. Dev. 0.52

TABLE G.10

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test	Apparent Inte laminar Shear; ASTM-D2344	(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #7					Tested By:	PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BI_-GR-17-3	72°F (DRY)	1.002	0.1711	2.816	1,188	5.196	4/17/89	
BI_-GR-17-11	"	1.002	0.1771	2.816	1,333	5.637	"	
BI_-GR-17-24	"	1.000	0.1764	2.816	1,338	5.688	"	
BI_-GR-17-33	"	1.000	0.1817	2.816	1,526	6.301	"	
BI_-GR-17-37	"	0.999	0.1738	2.816	1,275	5.506	"	
					Average	5.665		
					Std. Dev.	0.403		

SI Conversion
Ultimate Shear Strength (MPa)
35.82
38.86
39.22
43.44
37.96
Average 39.06
Std. Dev. 2.78

TABLE G.11

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear: ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #2 Task #7 Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-18-1	72°F (DRY)	1.002	0.1682	2.816	1,077	4.794	4/17/89	
BIL-GR-18-4	"	1.000	0.1683	2.816	1,455	6.481	"	
BIL-GR-18-7	"	1.002	0.1806	2.816	1,515	6.277	"	
BIL-GR-18-10	"	1.002	0.1703	2.816	1,277	5.613	"	
BIL-GR-18-13	"	1.000	0.1889	2.816	1,439	5.712	"	
					Average	5.776		
					Std. Dev.	0.660		

SI Conversion

Ultimate Shear Strength (MPa)
33.05
44.69
43.28
38.70
39.39
Average 39.82
Std. Dev. 4.55

TABLE G.12

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #3 Task #7 Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-19-1	72°F (DRY)	1.003	0.1676	2.816	1,181	5.270	4/17/89	
BIL-GR-19-4	"	1.000	0.1771	2.816	1,304	5.522	"	
BIL-GR-19-7	"	1.001	0.1782	2.816	1,459	6.136	"	
BIL-GR-19-10	"	1.001	0.1689	2.816	1,234	5.471	"	
BIL-GR-19-13	"	1.002	0.1790	2.816	1,397	5.839	"	
					Average	5.648		
					Std. Dev.	0.341		

SI Conversion
Ultimate Shear Strength (MPa)
36.34
38.07
42.31
37.72
40.26
Average 38.94
Std. Dev. 2.35

TABLE G.13

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS.
GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #1 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-17-4	72°F (WET)	1.001	0.1716	2.827	1,001	4.369	12/7/89	(1,2)
BIL-GR-17-12	"	1.001	0.1759	2.827	1,129	4.808	"	(1,2)
BIL-GR-17-24	"	0.999	0.1735	2.827	1,062	4.597	"	(1,2)
BIL-GR-17-34	"	1.000	0.1804	2.827	1,305	5.424	"	(1,2)
BIL-GR-17-44	"	1.001	0.1727	2.827	1,047	4.543	"	(1,2)
					Average	4.748		
					Std. Dev.	0.409		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.19%

SI Conversion
Ultimate Shear Strength (MPa)
30.12
33.15
31.70
37.40
31.33
Average 32.74
Std. Dev. 2.82

TABLE G.14

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #2 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-18-2	72°F (WET)	1.002	0.1746	2.827	1,048	4.495	12/7/89	(1,2)
BIL-GR-18-5	"	1.002	0.1821	2.827	1,136	4.670	"	(1,2)
BIL-GR-18-8	"	1.002	0.1773	2.827	1,167	4.927	"	(1,2)
BIL-GR-18-11	"	1.006	0.1809	2.827	1,134	4.676	"	(1,2)
BIL-GR-18-14	"	1.000	0.1887	2.827	1,232	4.899	"	(1,2)
					Average	4.733		
					Std. Dev.	0.180		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.32%

SI Conversion
Ultimate Shear Strength (MPa)
30.99
32.20
33.97
32.24
33.78
Average 32.64
Std. Dev. 1.24

TABLE G.15

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #3 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-19-2	72°F (WET)	1.000	0.1718	2.827	1,036	4.522	12/7/89	(1,2)
BIL-GR-19-5	"	1.002	0.1741	2.827	1,079	4.641	"	(1,2)
BIL-GR-19-8	"	1.000	0.1733	2.827	1,037	4.486	"	(1,2)
BIL-GR-19-11	"	1.001	0.1758	2.827	1,089	4.644	"	(1,2)
BIL-GR-19-14	"	1.002	0.1776	2.827	1,128	4.754	"	(1,2)
					Average	4.609		
					Std. Dev.	0.107		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.24%

SI Conversion
Ultimate Shear Strength (MPa)
31.18
32.00
30.93
32.02
32.78
Average 31.78
Std. Dev. 0.74

TABLE G.16

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344				(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation: Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #7			Tested By: DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-17-5	200°F (WET)	1.001	0.1802	2.846	564	2.345	12/7/89	(1,2)
BIL-GR-17-13	"	1.000	0.1716	2.846	432	1.890	"	(1,2)
BIL-GR-17-26	"	0.999	0.1752	2.846	470	2.011	"	(1,2)
BIL-GR-17-35	"	1.001	0.1792	2.846	473	1.975	"	(1,2)
BIL-GR-17-43	"	1.001	0.1761	2.846	490	2.084	"	(1,2)
					Average	2.061		
					Std. Dev.	0.173		

Remarks:

(1) Specimens aged @ 140°F/85-100% R.H. to saturation.

(2) Average weight gain = 2.22%

SI Conversion
Ultimate Shear Strength (MPa)
16.17
13.03
13.87
13.62
14.37
Average 14.21
Std. Dev. 1.19

TABLE G.17

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Batch #2 Task #7 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-18-3	200°F (WET)	1.002	0.1787	2.846	565	2.366	12/7/89	(1,2)
BIL-GR-18-6	"	1.004	0.1816	2.846	538	2.212	"	(1,2)
BIL-GR-18-9	"	1.002	0.1725	2.846	521	2.260	"	(1,2)
BIL-GR-18-12	"	0.999	0.1832	2.846	541	2.215	"	(1,2)
BIL-GR-18-15	"	1.000	0.1873	2.846	549	2.197	"	(1,2)
					Average	2.250		
					Std. Dev.	0.069		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.32%

SI Conversion
Ultimate Shear Strength (MPa)
16.31
15.25
15.58
15.27
15.15
Average 15.51
Std. Dev. 0.47

TABLE G.18

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:	Warp
Material .	EA-9396 A/B; W133 Graphite	Batch #3	Task #7				Tested By:	DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-19-3	200°F (WET)	0.999	0.1761	2.846	662	2.820	12/7/89	(1,2)
BIL-GR-19-6	"	1.002	0.1757	2.846	665	2.833	"	(1,2)
BIL-GR-19-9	"	1.000	0.1716	2.846	571	2.493	"	(1,2)
BIL-GR-19-12	"	1.001	0.1774	2.846	632	2.667	"	(1,2)
BIL-GR-19-15	"	1.002	0.1716	2.846	634	2.765	"	(1,2)
					Average	2.716		
					Std. Dev.	0.140		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.24%

SI Conversion
Ultimate Shear Strength (MPa)
19.44
19.53
17.19
18.39
19.06
Average 18.72
Std. Dev. 0.97

APPENDIX H
INDIVIDUAL SPECIMEN BEARING PROPERTIES, BASELINE

The four tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in bearing. A summary of these data was presented and discussed in Section 3.4.

TABLE H.1

INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
GLASS REINFORCEMENT, DRY CONDITION

Test : Bolt-Bearing; ASTM-D953 — Fiber Orientation : $(0°/\pm45°/90°)_s$

Material : EA-9396 A/B; 7781 Glass — Batch #1 Task #10 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diamete (in.)	Load at 4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Ultimate Load (lbs.)	% Elong. @ Ult. Load (%)	Date Tested	Remarks
BIL-GL-22-1	72°F (DRY)	1.498	0.0631	0.2515	660	900	41.59	56.71	12.80	900	12.00	7/14/89	
BIL-GL-22-5	"	1.499	0.0649	0.2518	713	846	43.62	51.75	12.00	850	12.30	"	
BIL-GL-22-7	"	1.498	0.0647	0.2517	686	916	42.11	56.23	11.00	920	11.38	"	
					Average		42.44	54.90	11.93		11.89		
					Std. Dev.		1.06	2.74	0.90		0.47		

Remarks:

(1) Type of failure:
- a) tension.
- b) shear-out
- c) cleavage-tension.
- d) bearing.

SI Conversion

Bearing Strength (MPa)	Maximum Bearing Strength (MPa)
286.8	391.0
300.8	356.8
290.3	387.7
Average 292.6	378.5
Std. Dev. 7.3	18.9

TABLE H.2

INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
GLASS REINFORCEMENT, WET CONDITION

Test : Bolt-Bearing; ASTM-D953 — Fiber Orientation : $(0°/\pm45°/90°)_s$

Material : EA-9396 A/B; 7781 Glass — Batch #1 Task #10 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diamete (in.)	Load at 4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Ultimate Load (lbs.)	% Elong. @ Ult. Load (%)	Date Tested	Remarks
BIL-GL-22-2	72°F (WET)	1.498	0.0651	0.2499	381	555	23.42	34.12	9.36	NA	NA	2/26/90	(1a,2,3)
BIL-GL-22-4	"	1.499	0.0645	0.2505	375	615	23.21	38.06	10.52	NA	NA	"	(1a,2,3)
BIL-GL-22-8	"	1.498	0.0640	0.2512	292	532	18.16	33.09	28.72	532	28.72	"	(1a,2,3)
						Average	21.60	35.09	16.20				
						Std. Dev.	2.98	2.63	10.86				

Remarks:

(1) Type of failure:
   a) tension.
   b) shear-out
   c) cleavage-tension.
   d) bearing.

(2) Specimens aged @ 140°F/95-100% R.H. for 148 days to saturation.

(3) Average weight gain = 0.6418%

SI Conversion

	Bearing Strength (MPa)	Maximum Bearing Strength (MPa)
	161.5	235.2
	160.0	262.4
	125.2	228.2
Average	148.9	241.9
Std. Dev.	20.5	18.1

TABLE H.3

INDIVUDAL SPECIMEN BOLT-BEARING TEST RESULTS,
GRAPHITE REINFORCEMENT, DRY CONDITION

Test : Bolt-Bearing; ASTM-D953 — Fiber Orientation : $(0°/\pm45°/90°)_s$

Material : EA-9396 A/B ; W133 Graphite — Batch #1 Task #10 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diamete (in.)	Load at 4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Ultimate Load (lbs.)	% Elong. @ Ult. Load (%)	Date Tested	Remarks
BIL-GR-43-1	72°F (DRY)	1.499	0.1154	0.2502	1,482	1,861	51.33	64.44	1.50	1,875	6.63	7/14/89	
BIL-GR-43-5	"	1.499	0.1232	0.2505	1,575	2,204	51.03	71.40	3.50	2,250	10.75	"	
BIL-GR-43-7	"	1.500	0.1196	0.2508	2,179	2,339	72.63	77.99	5.25	2,350	12.88	"	
						Average	58.33	71.28	3.42		10.09		
						Std. Dev.	12.38	6.77	1.88		3.18		

Remarks:

(1) Type of failure:
- a) tension.
- b) shear-out
- c) cleavage-tension.
- d) bearing.

SI Conversion

	Bearing Strength (MPa)	Maximum Bearing Strength (MPa)
	353.9	444.3
	351.9	492.3
	500.8	537.7
Average	402.2	491.5
Std. Dev.	85.4	46.7

TABLE H.4

INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
GRAPHITE REINFORCEMENT, WET CONDITION

Test : Bolt-Bearing; ASTM-D953 — Fiber Orientation : $(0°/\pm45°/90°)_s$

Material : EA-9396 A/B; W133 Graphite — Batch #1 Task #10 — Tested by : PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diamete (in.)	Load at 4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Ultimate Load (lbs.)	% Elong. @ Ult. Load (%)	Date Tested	Remarks
BIL-GR-43-2	72°F (WET)	1.501	0.1224	0.2512	930	2,660	30.25	86.51	19.64	2,660	19.64	2/26/90	(1a,2,3)
BIL-GR-43-4	"	1.500	0.1224	0.2509	1,040	2,750	33.87	89.55	22.32	2,700	23.20	"	(1a,2,3)
BIL-GR-43-6	"	1.499	0.1209	0.2510	1,125	2,760	37.07	90.95	20.28	2,725	22.08	"	(1a,2,3)
					Average		33.73	89.00	20.75		21.64		
					Std. Dev.		3.41	2.27	1.40		1.82		

Remarks:

(1) Type of failure:
- a) tension.
- b) shear-out
- c) cleavage-tension.
- d) bearing.

(2) Specimens aged @ 140°F/95-100% R.H. for 148 days to saturation.

(3) Average weight gain = 0.6129%

SI Conversion

	Bearing Strength (MPa)	Maximum Bearing Strength (MPa)
	208.6	596.5
	233.5	617.4
	255.6	627.1
Average	232.6	613.7
Std. Dev.	23.5	15.6

APPENDIX I

INDIVIDUAL SPECIMEN GLASS TRANSITION TEMPERATURE MEASUREMENTS

This appendix presents the results of the glass transition temperature (Tg) measurements on each individual specimen. The specimens were in the form of neat resin castings with approximate dimensions of 22 x 13 x 2 mm (7/8 x 1/2 x 1/16 inch). The measurements were performed by dynamic mechanical analysis (DMA) at a heating rate of 0.5°C/minute. Glass transition temperature was taken from the peak of the log E" (loss modulus) vs. temperature curve. The tests were performed on a DuPont Model 983 DMA. Table I.1 summarizes the individual results and Figures I.1-I.18 illustrate the DMA curves for each specimen. The curves for specimen Nos. 1-2 (I.1) and 1-1 (I.10) are labelled to indiciate the location at which the Tg was identified for the dry and wet test conditions.

TABLE I.1

INDIVIDUAL SPECIMEN GLASS TRANSITION TEMPERATURE

Specimen Number	Batch Number	Test Condition	Wt. Gain (%) (1)	Glass Transition Temp.(2) (°C)	(°F)
1-2	1	Dry	N.A.	174	345
1-4	1	Dry	N.A.	176	349
1-6	1	Dry	N.A.	175	347
Avg.				175	347
Std. Dev.				1.0	2.0
2-2	2	Dry	N.A.	176	349
2-4	2	Dry	N.A.	176	349
2-6	2	Dry	N.A.	177	351
Avg.				176	350
Std. Dev.				0.6	1.0
3-2	3	Dry	N.A.	177	351
3-4	3	Dry	N.A.	178	352
3-6	3	Dry	N.A.	176	349
Avg.				177	351
Std. Dev.				1.0	1.5
1-1	1	Wet	9.2	107	225
1-3	1	Wet	9.1	106	223
1-5	1	Wet	9.1	106	223
Avg.				106	224
Std. Dev.				0.6	1.0
2-1	2	Wet	8.7	108	226
2-3	2	Wet	8.6	111	
2-5	2	Wet	8.9	106	223
Avg.				108	227
Std. Dev.				2.5	4.6
3-1	3	Wet	8.8	109	228
3-3	3	Wet	8.9	107	225
3-5	3	Wet	8.7	105	221
Avg.				107	225
Std. Dev.				2.0	3.5

NOTES: (1) After aging at 60°C (140°F) and 95-100% R.H. until saturated.
(2) Specimens cured for 45 minutes at 93°C (200°F).

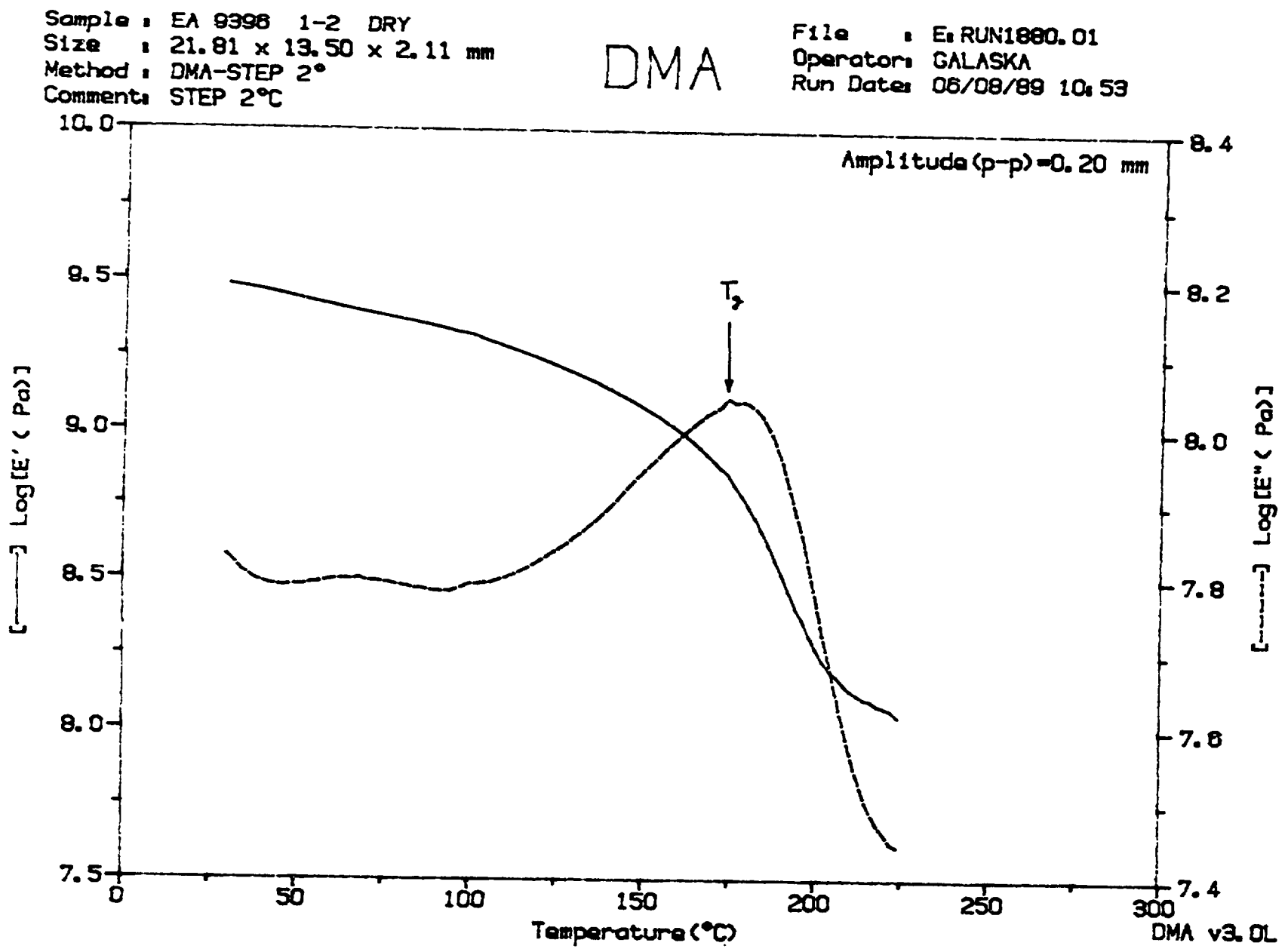


Figure I.1. Determination of Tg for Specimen 1-2, Batch 1, Dry Condition.

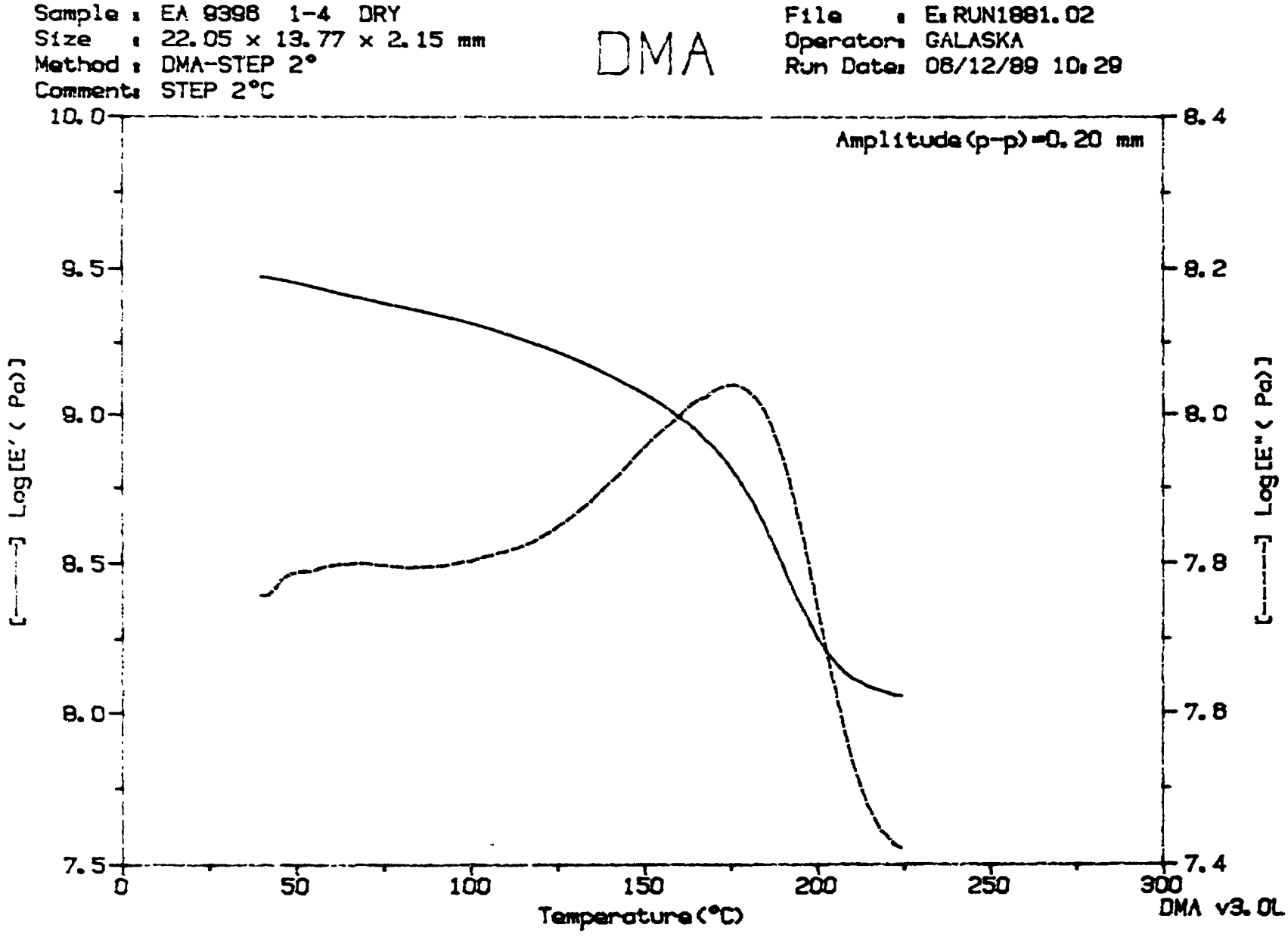


Figure I.2. Determination of Tg for Specimen 1-4, Batch 1, Dry Condition.

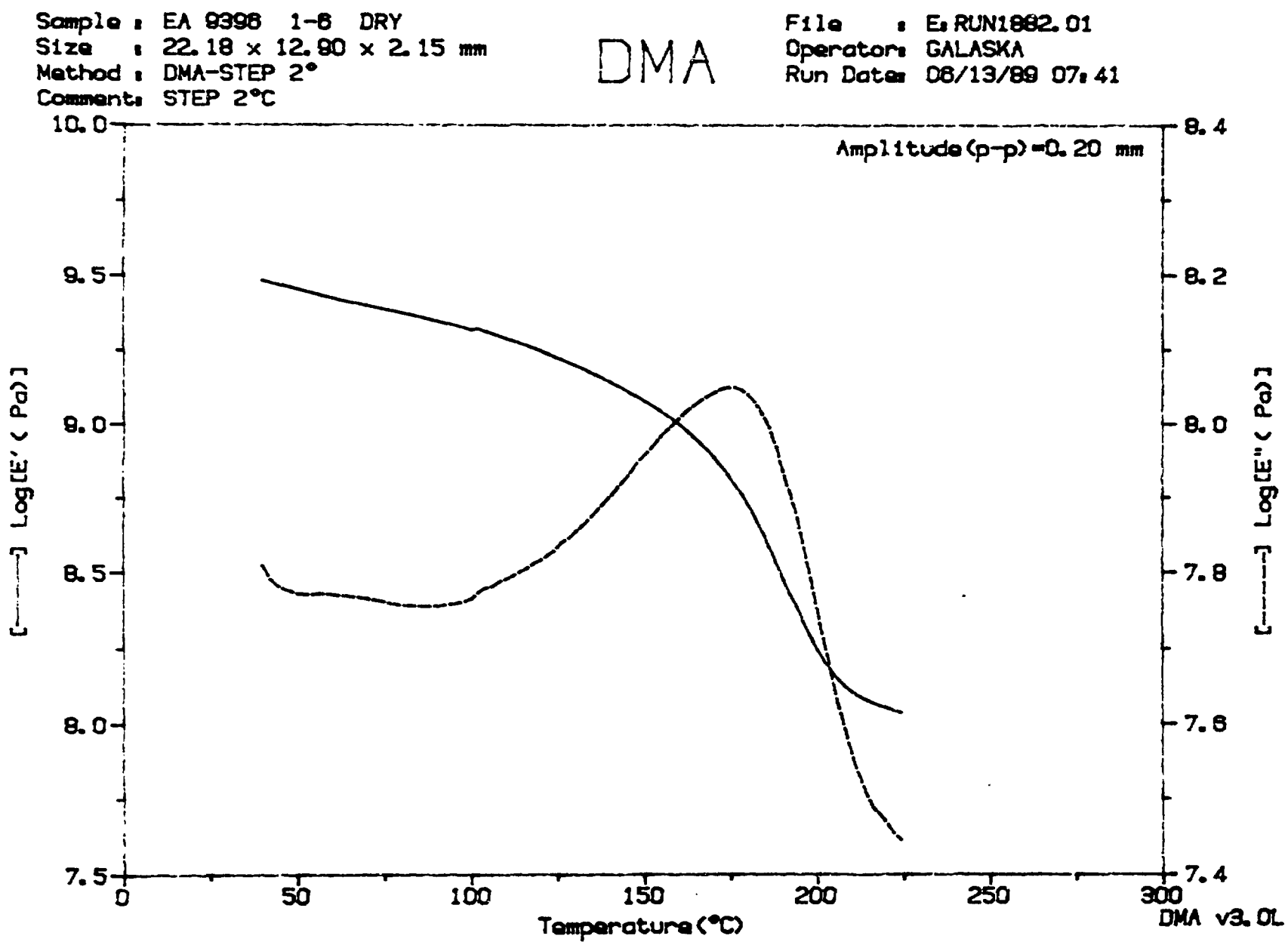


Figure I.3. Determination of Tg for Specimen 1-6, Batch 1, Dry Condition.

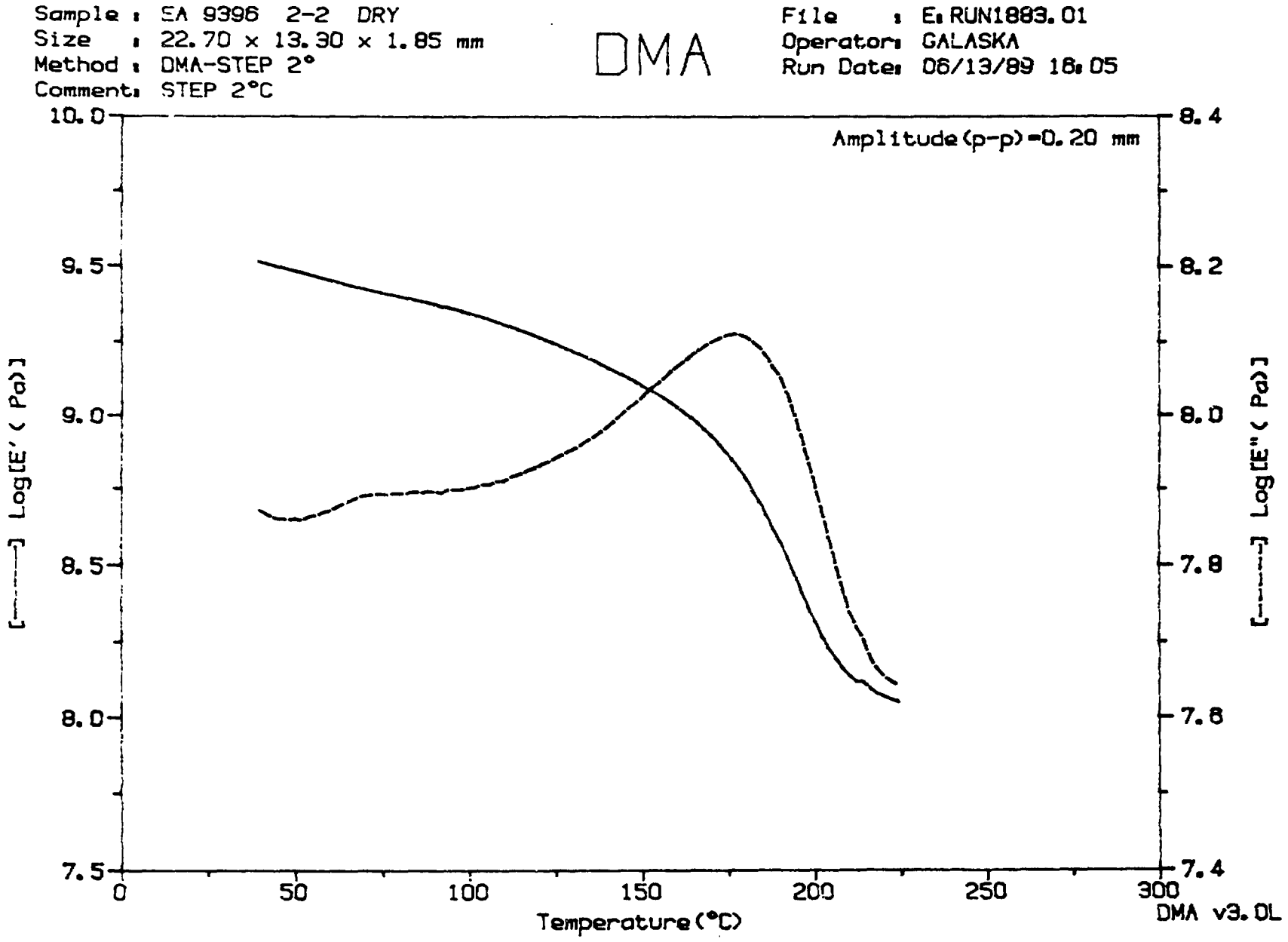


Figure I.4. Determination of Tg for Specimen 2-2, Batch 2, Dry Condition.

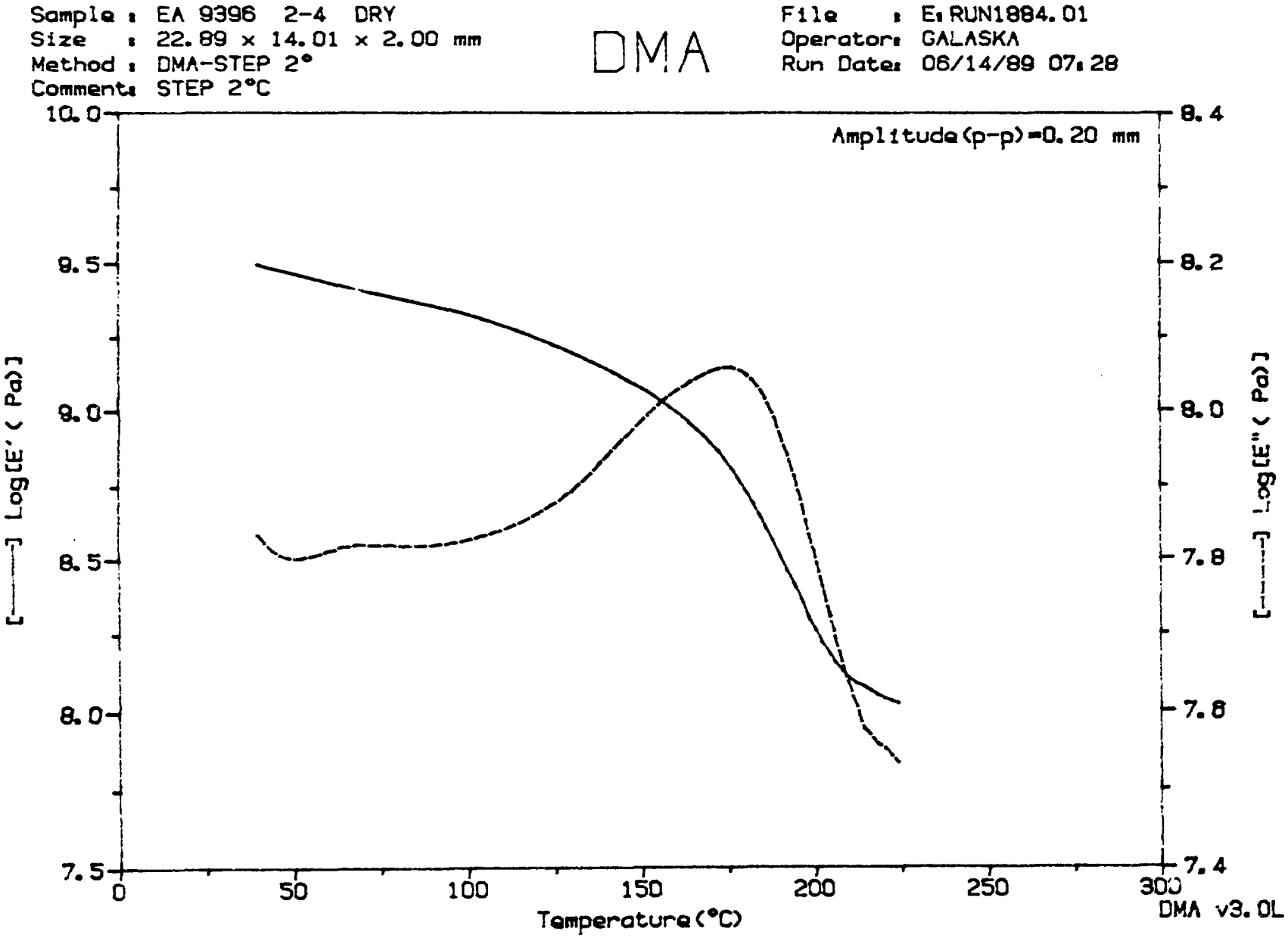


Figure 1.5. Determination of Tg for Specimen 2-4, Batch 2, Dry Condition.

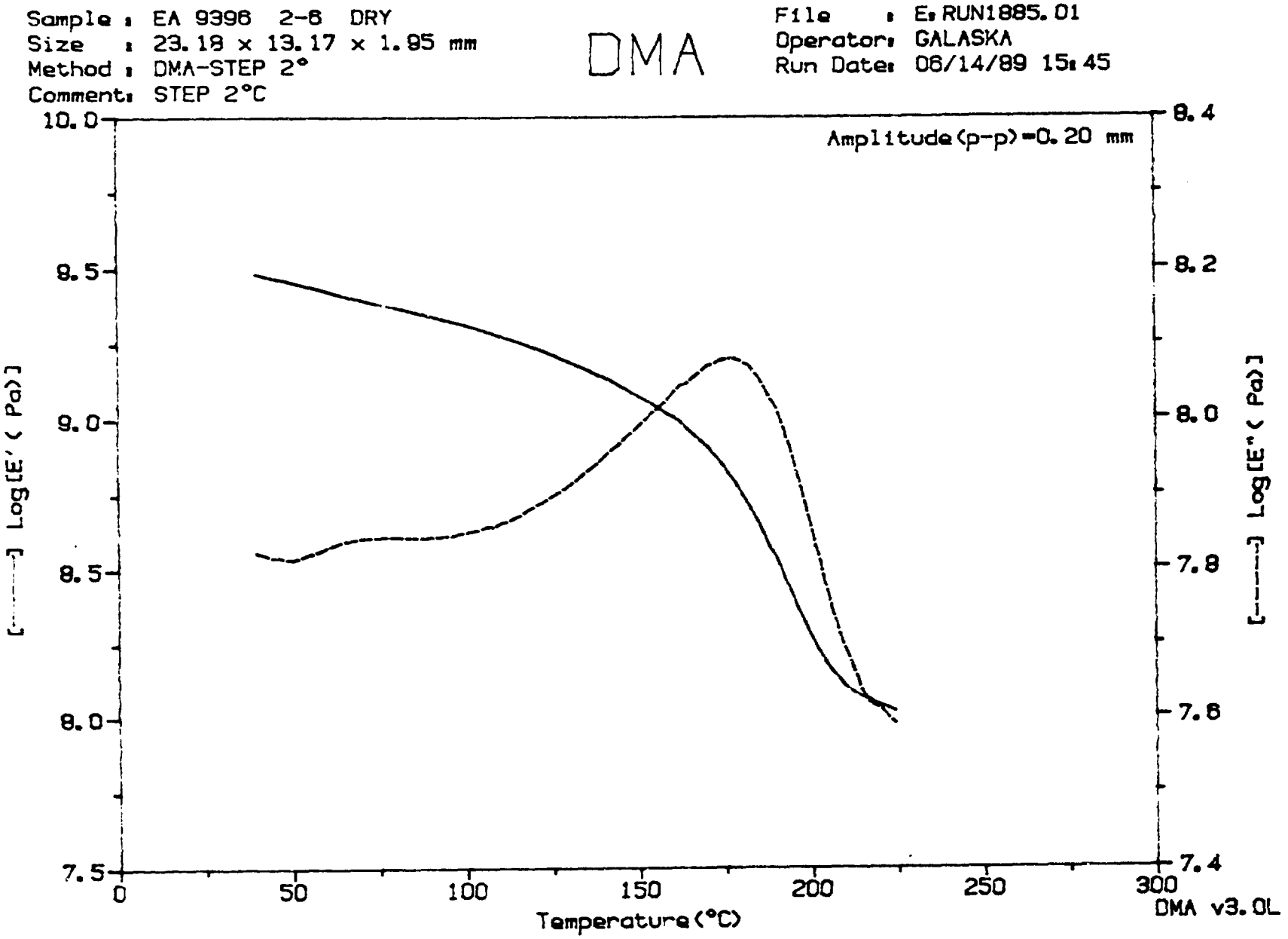


Figure 1.6. Determination of Tg for Specimen 2-6, Batch 2, Dry Condition.

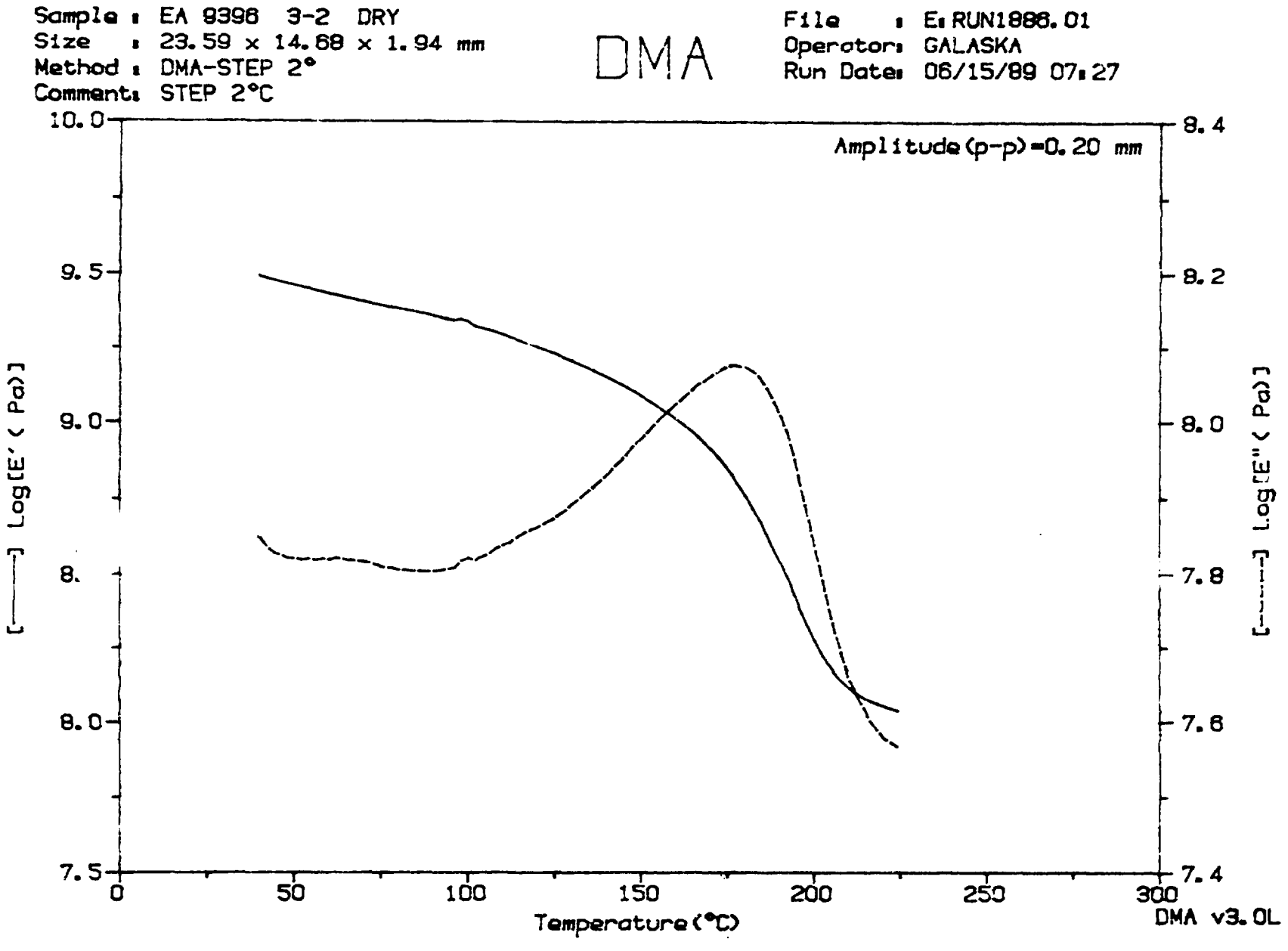


Figure I.7. Determination of Tg for Specimen 3-2, Batch 3, Dry Condition.

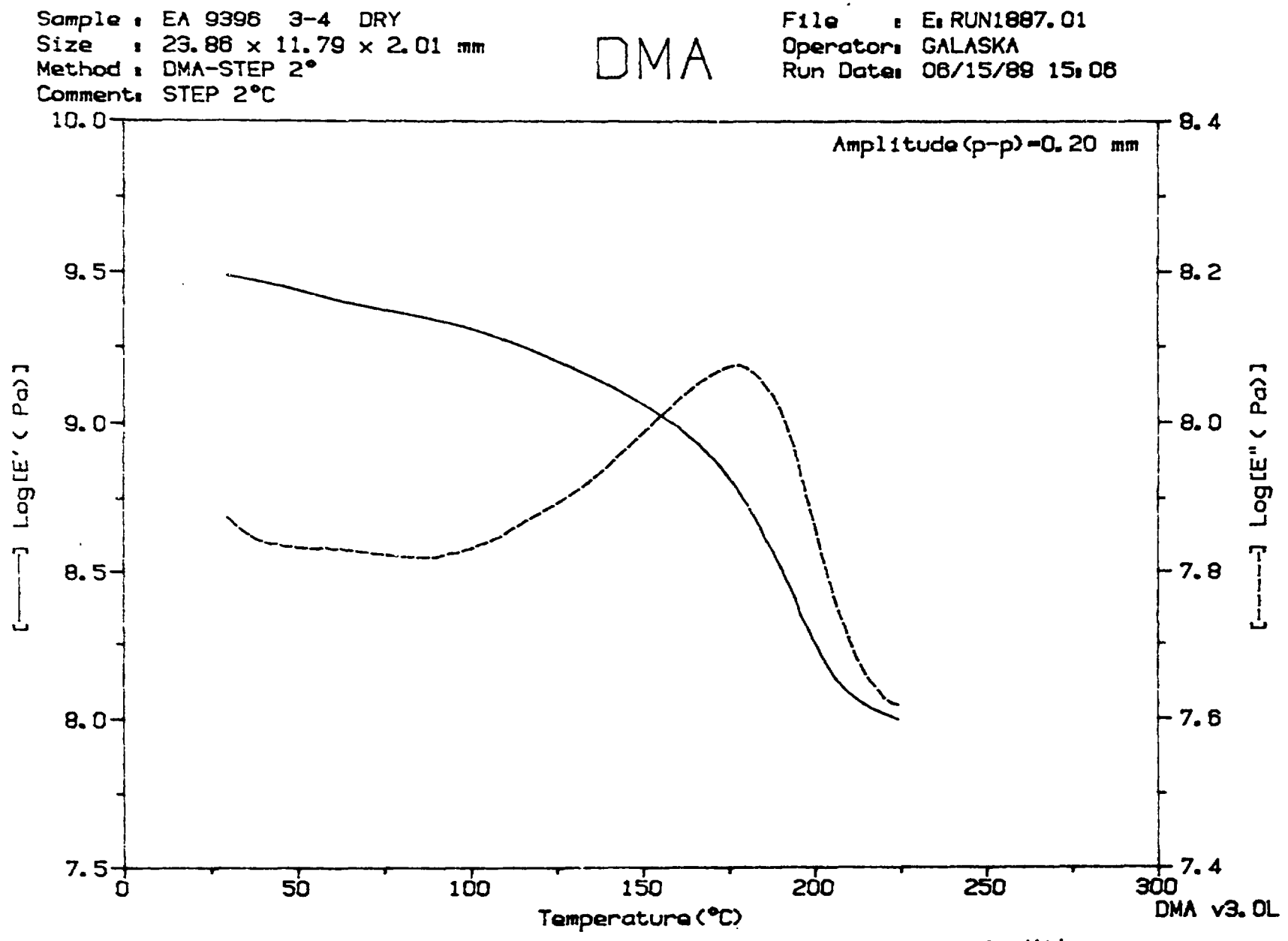


Figure I.8. Determination of Tg for Specimen 3-4, Batch 3, Dry Condition.

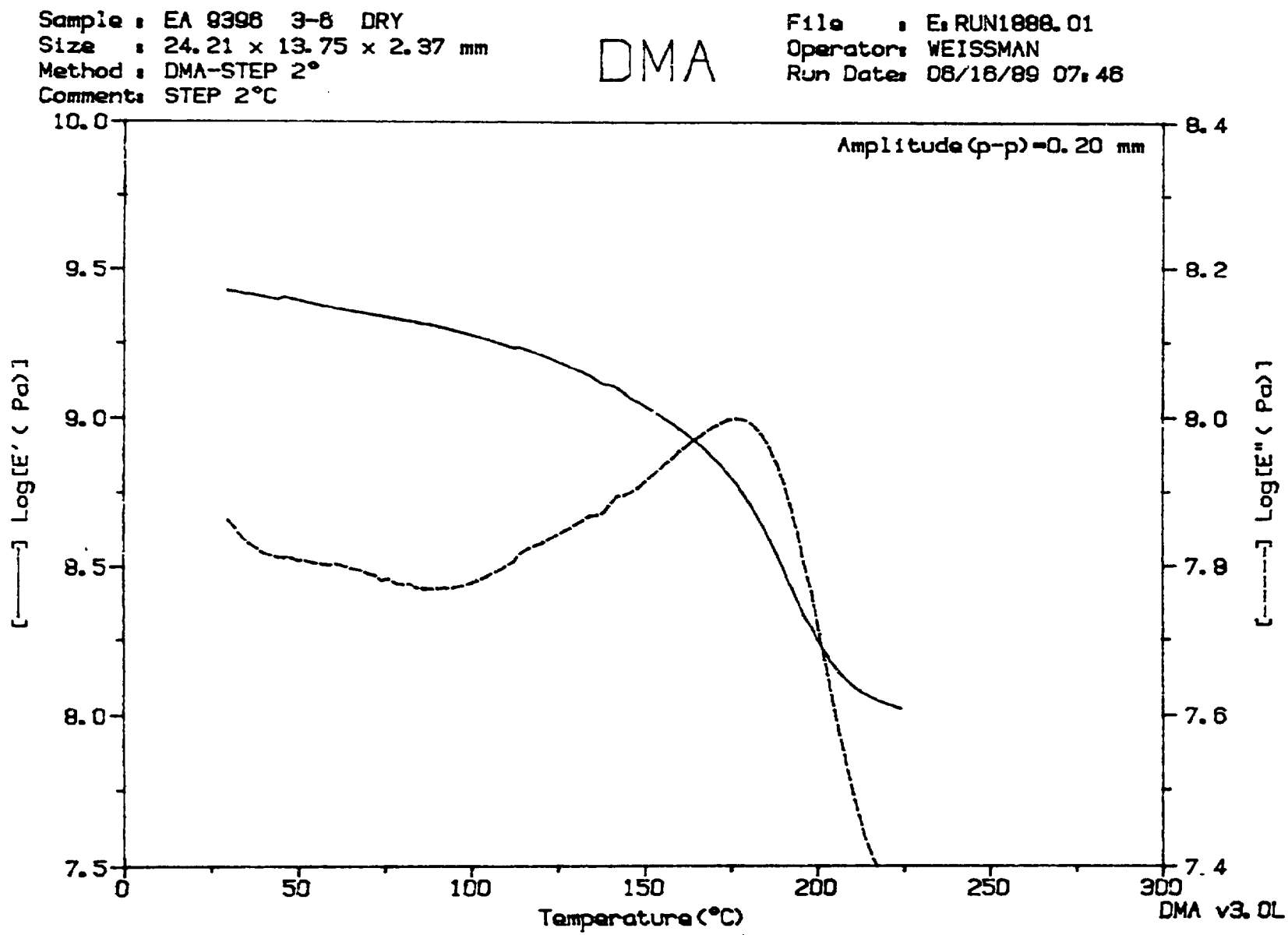


Figure I.9. Determination of Tg for Specimen 3-6, Batch 3, Dry Condition.

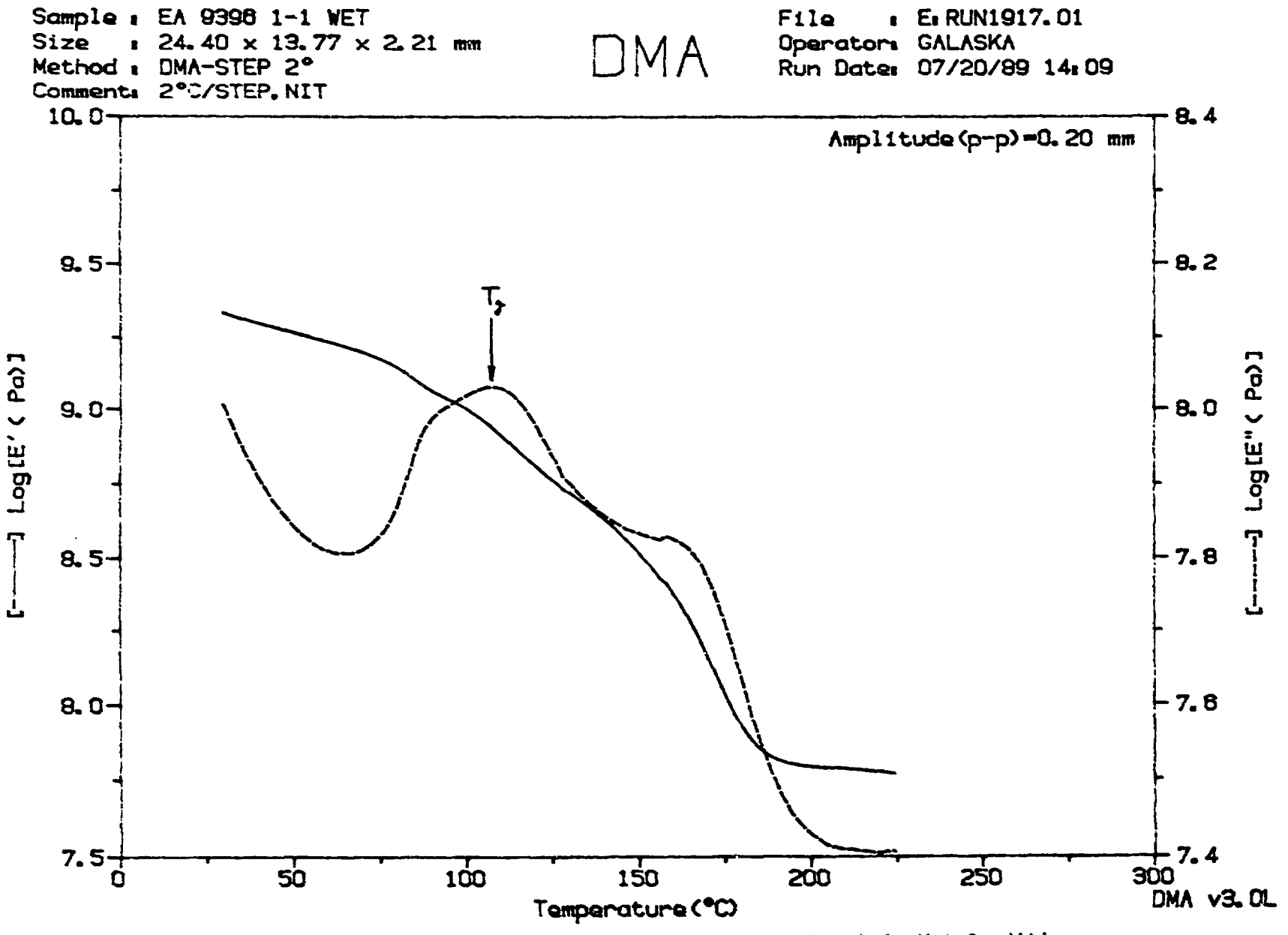


Figure I.10. Determination of Tg for Specimen 1-1, Batch 1, Wet Condition.

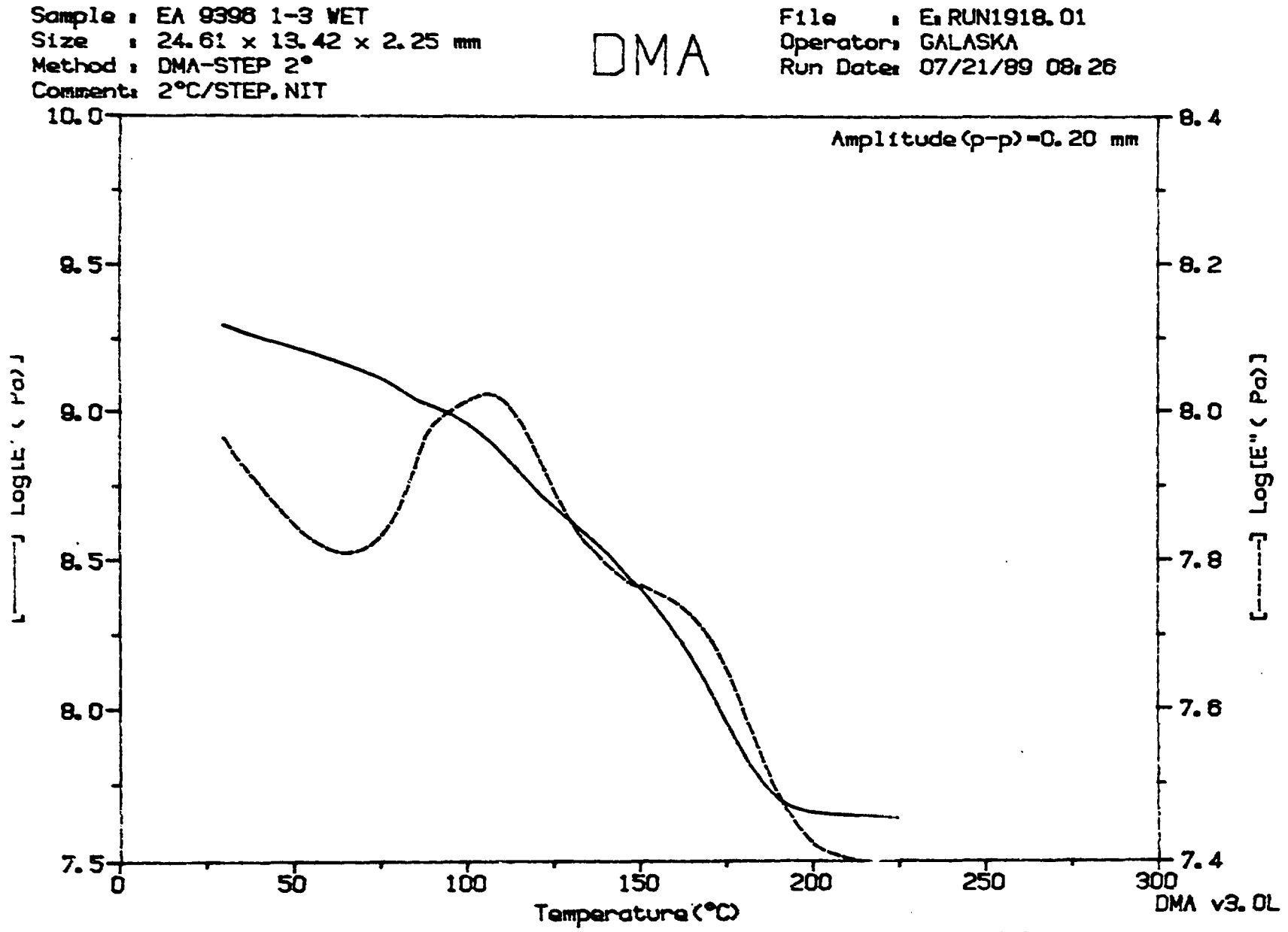


Figure I.11. Determination of Tg for Specimen 1-3, Batch 1, Wet Condition.

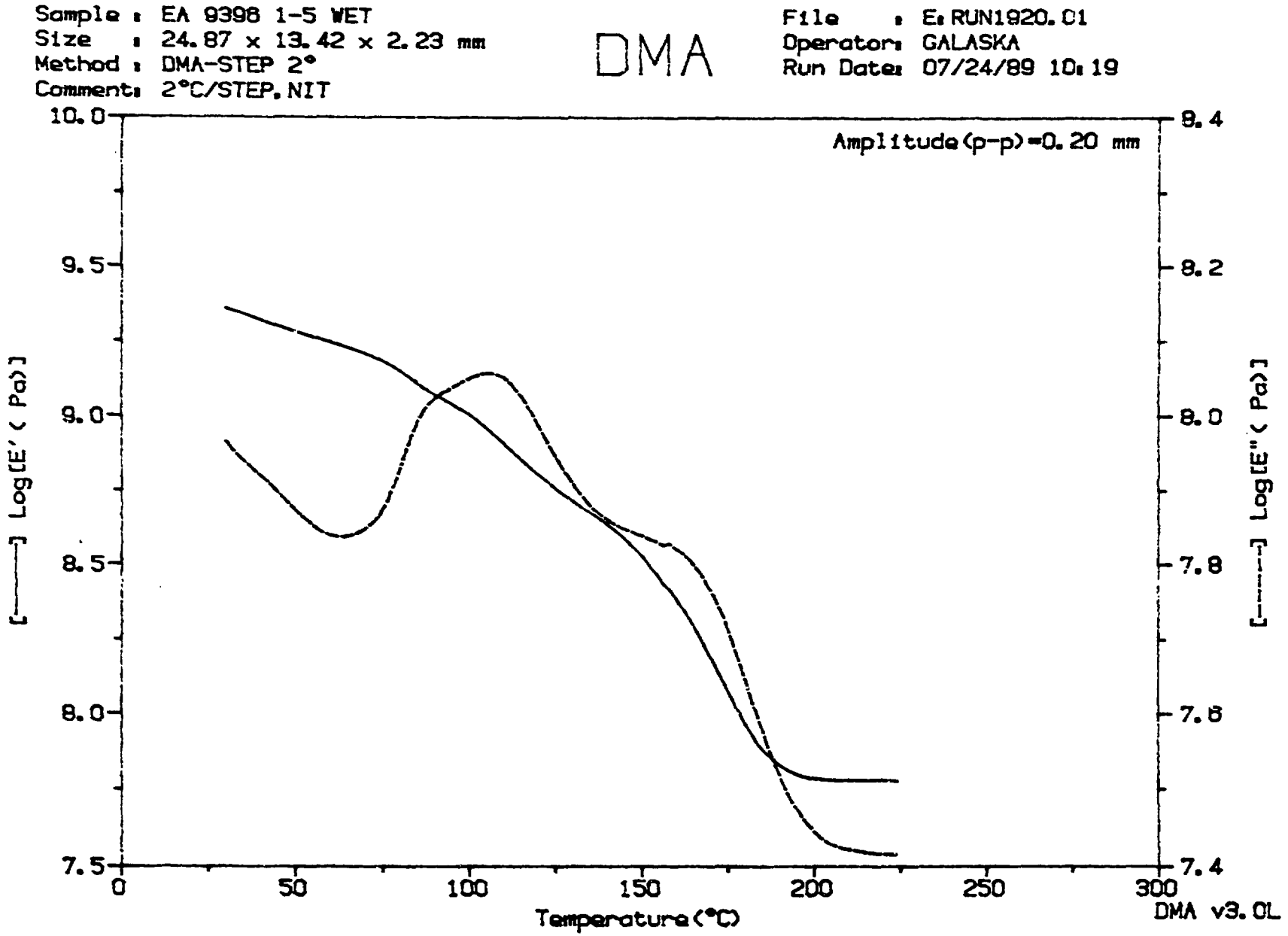


Figure I.12. Determination of Tg for Specimen 1-5, Batch 1, Wet Condition.

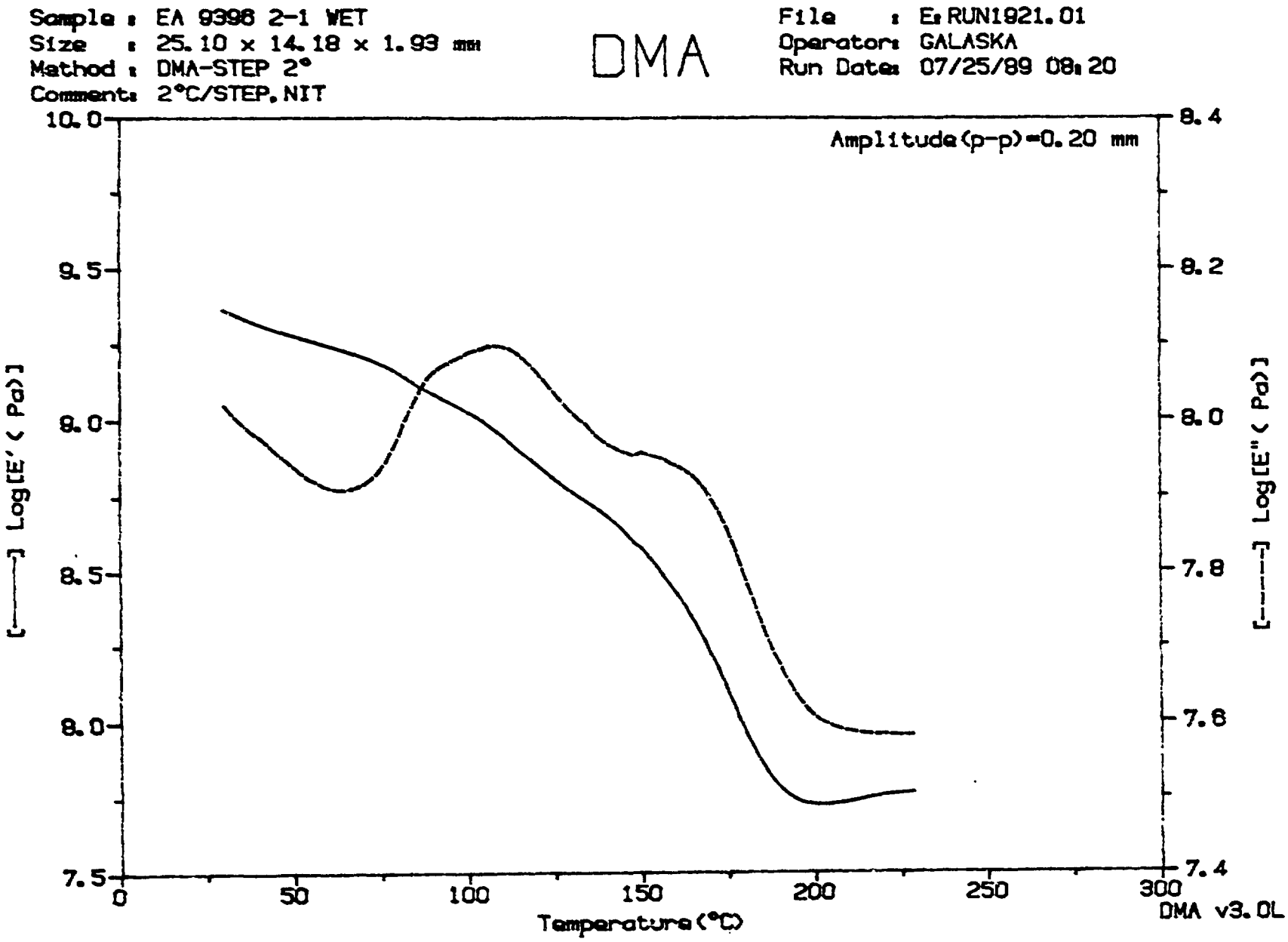


Figure I.13. Determination of Tg for Specimen 2-1, Batch 2, Wet Condition.

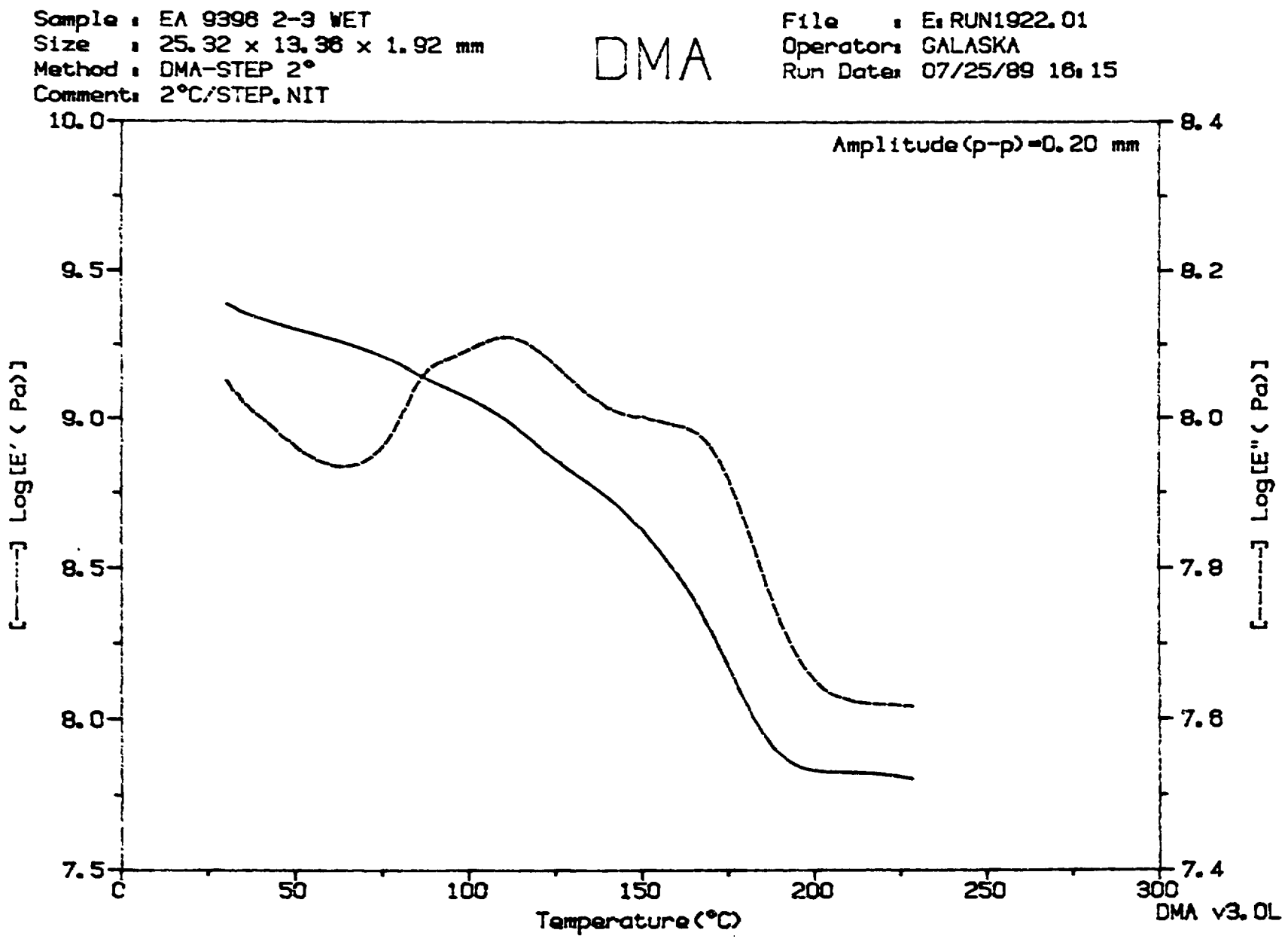


Figure I.14. Determination of Tg for Specimen 2-3, Batch 2, Wet Condition.

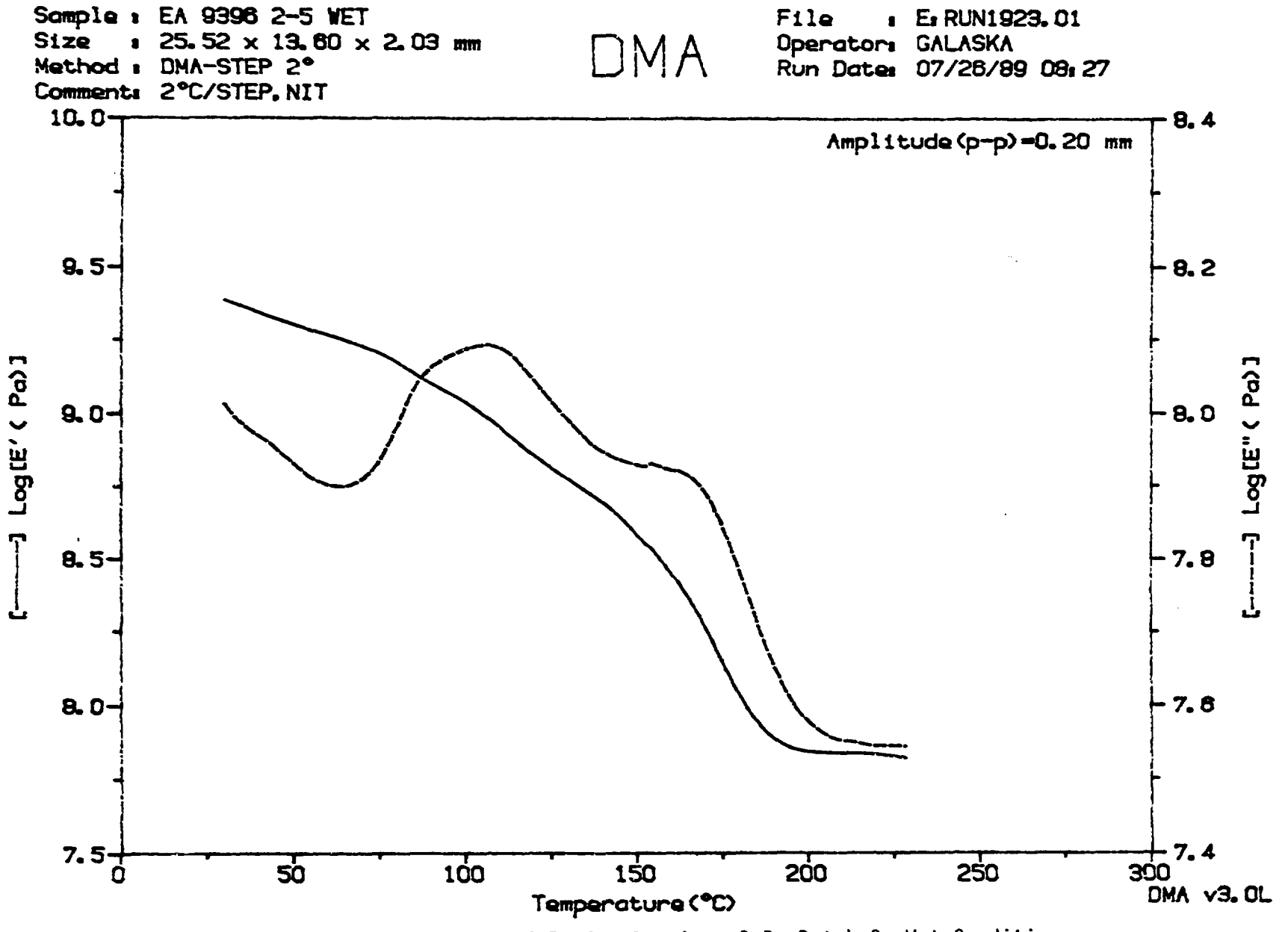


Figure I.15. Determination of Tg for Specimen 2-5, Batch 2, Wet Condition.

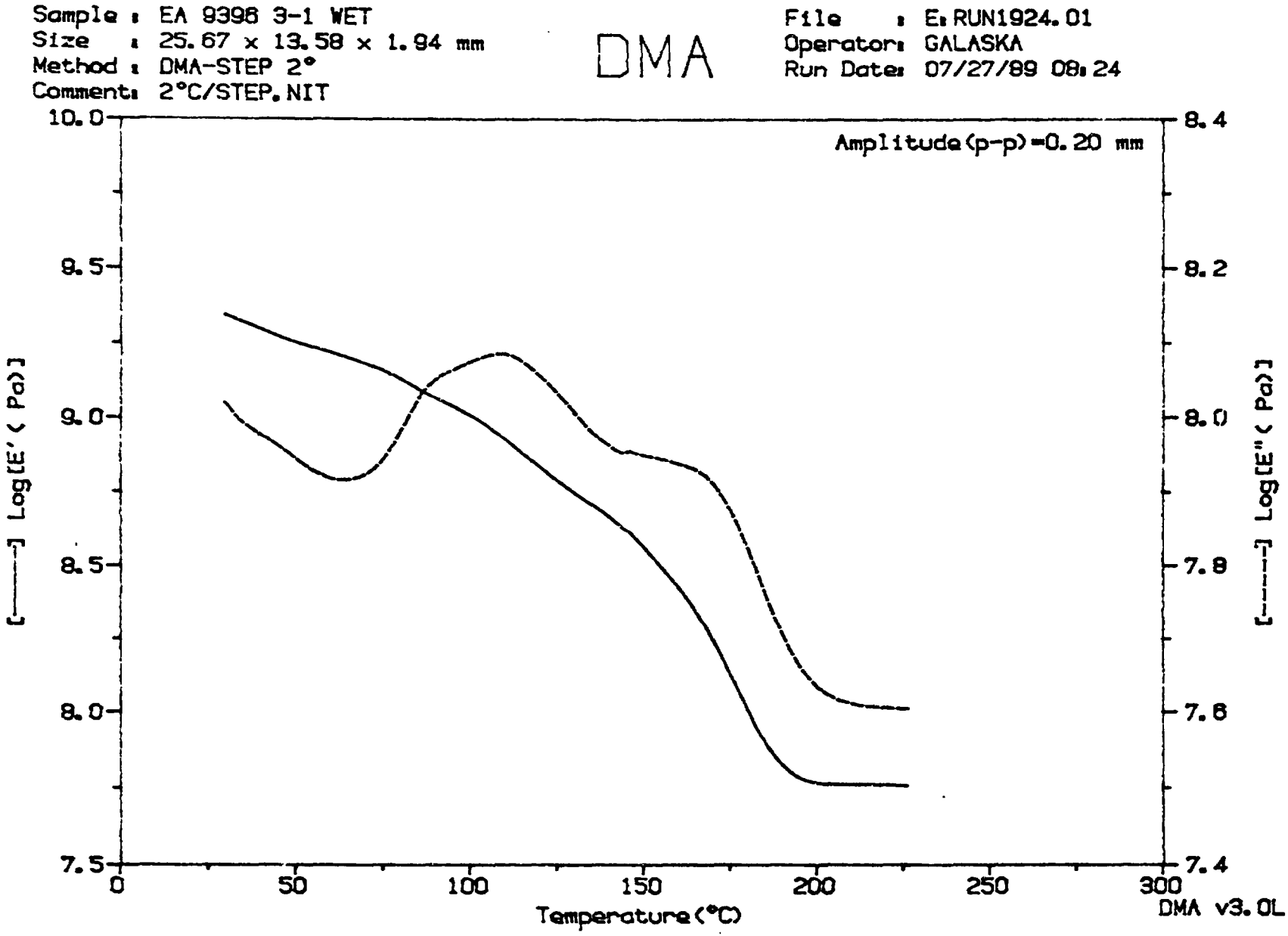


Figure I.16. Determination of Tg for Specimen 3-1, Batch 3, Wet Condition.

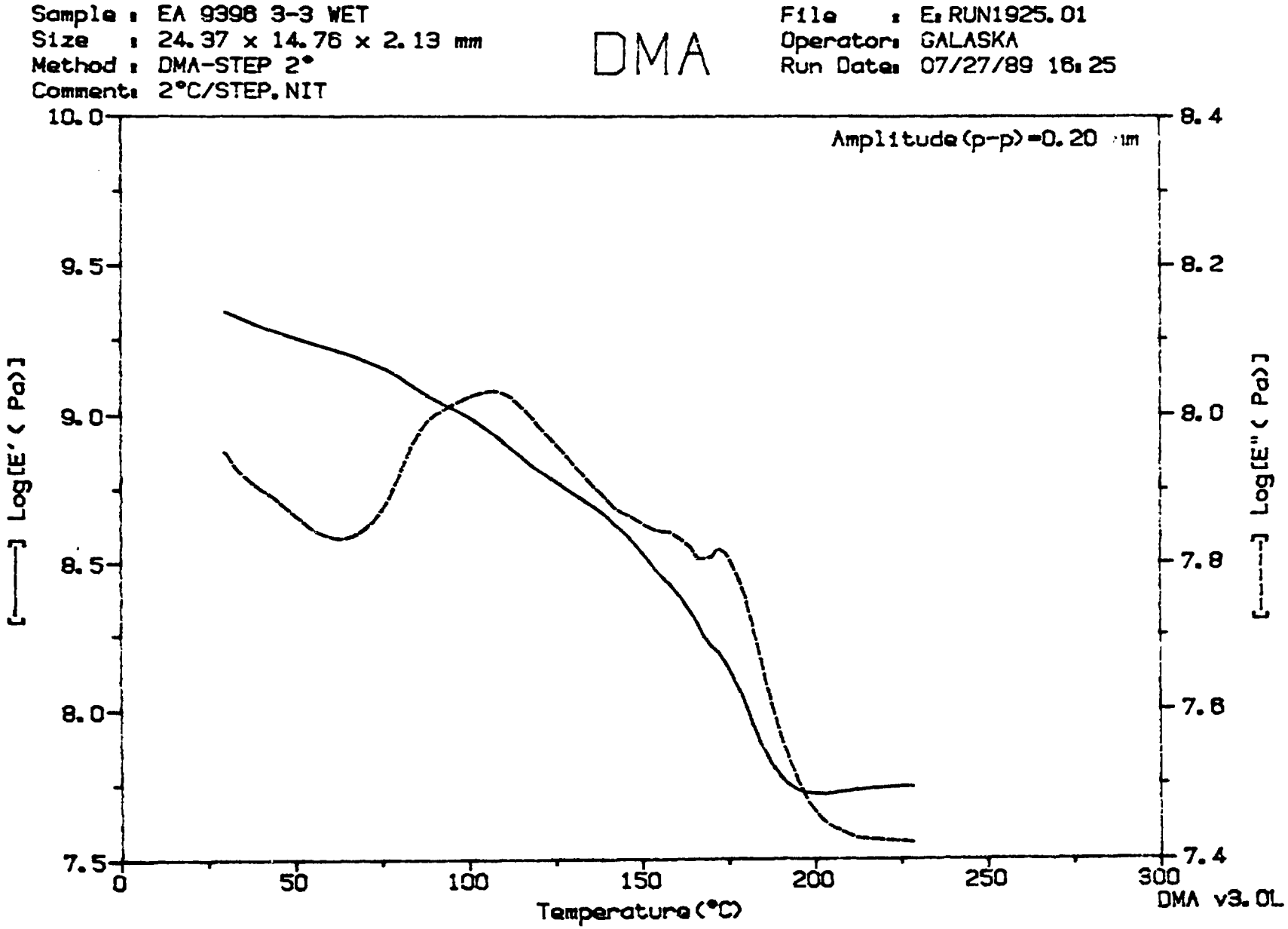


Figure I.17. Determination of Tg for Specimen 3-3, Batch 3, Wet Condition.

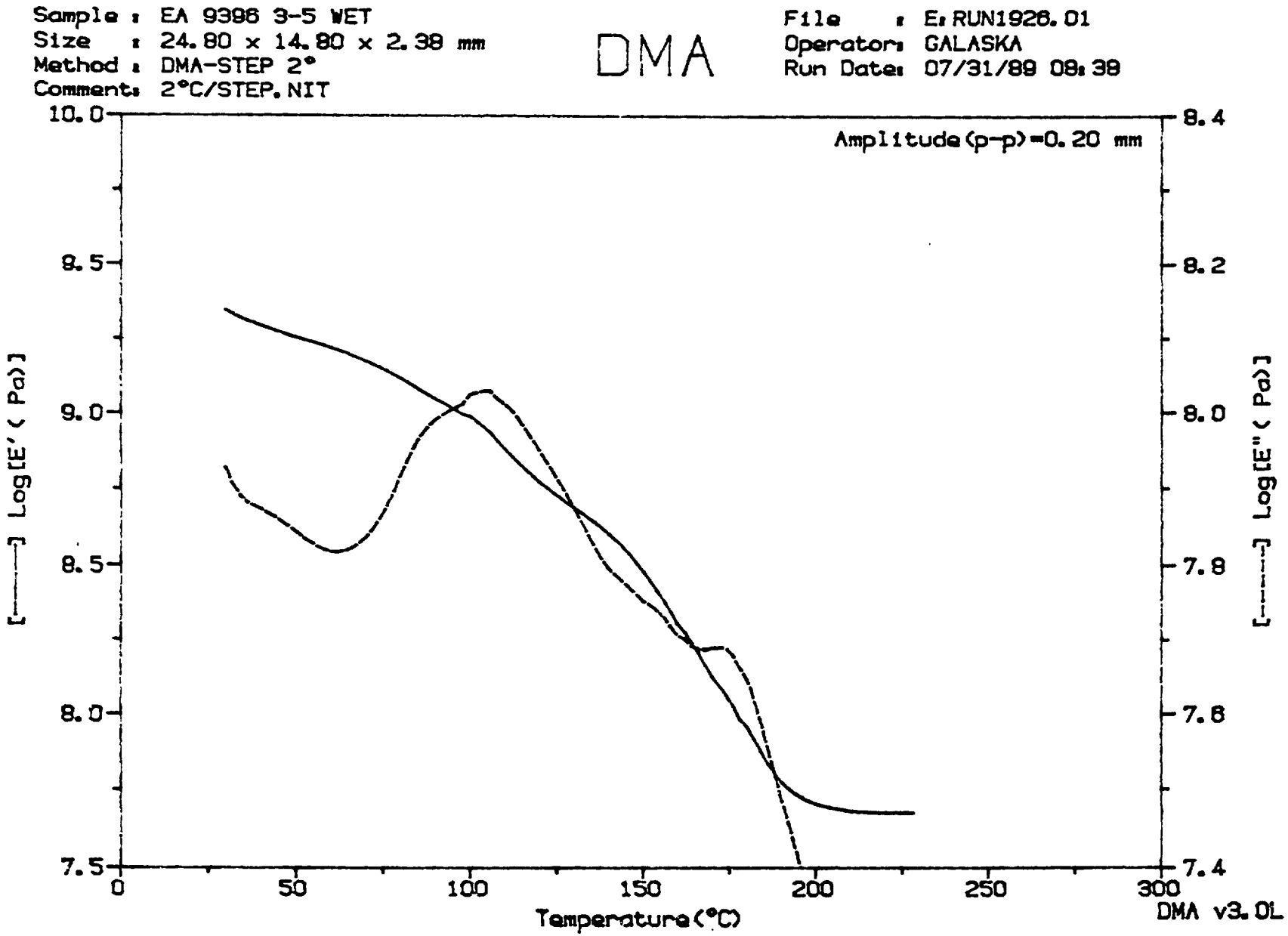


Figure I.18. Determination of Tg for Specimen 3-5, Batch 3, Wet Condition.

APPENDIX J

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR STRENGTHS, EFFECT OF CURE TIME/TEMPERATURE/ PRESSURE VARIATIONS

The six tables in this appendix present the detailed interlaminar shear strength data for specimens prepared with nonstandard cure schedules. These nonstandard cure schedules involved curing at temperatures and vacuum pressures both above and below the baseline levels of 93°C (200°F) and 635 mm (25 in.) Hg, respectively, or for other than the standard cure time of 45 minutes. A summary of these data was presented and discussed in Section 3.5.2.

TABLE J.1

EFFECT OF CURE VACUUM PRESSURE ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)				Specimen Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #4	Task #17				Tested By:	DH
Specimen Number	Cure Pressure (1) (in. g. Vac.)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-27-A	10	0.500	0.1360	1.088	435	4.798	33.08	12/11/89	
BIL-GL-27-C	"	0.750	0.1340	1.072	500	4.478	30.87	"	
					Average	4.638	31.98		
					Std. Dev.	0.226	1.56		
BIL-GL-28-1	16	1.003	0.1292	1.050	888	5.139	35.44	10/26/89	
BIL-GL-28-3	"	1.003	0.1328	1.050	925	5.208	35.91	"	
					Average	5.174	35.67		
					Std. Dev.	0.049	0.34		
BIL-GL-29-1	23	1.002	0.1281	1.030	801	4.680	32.27	10/31/89	
BIL-GL-29-3	"	1.002	0.1290	1.030	832	4.828	33.29	"	
BIL-GL-29-C	"	0.500	0.1300	1.040	379	4.373	30.15	12/11/89	
					Average	4.627	31.90		
					Std. Dev.	0.232	1.60		
BIL-GL-38-1	27	0.997	0.1212	0.978	922	5.723	39.46	12/4/89	
BIL-GL-38-3	"	0.997	0.1224	0.978	917	5.636	38.86	"	
BIL-GL-38-5	"	0.996	0.1211	0.978	1,039	6.461	44.55	"	
					Average	5.940	40.95		
					Std. Dev.	0.453	3.13		

(1) All cures were at 93°C (200°F) for 45 minutes.

TABLE J.2

INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 45 MINUTES AT 107°C (225°F)

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)					Specimen Orientation: Warp		
Material :	EA-9396 A/B; W133 Graphite				Task #16			Tested By:		TOB
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thicknes (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-5-1	45 min. @	22°C (72°F) (DRY)	0.997	0.1732	2.800	1,448	6.289	43.36	1/23/89	
BIL-GR-5-3	107°C (225°F)	"	1.000	0.1743	2.800	1,496	6.437	44.38	"	
BIL-GR-5-5	"	"	0.995	0.1681	2.800	1,340	6.007	41.42	"	
BIL-GR-5-7	"	"	0.998	0.1739	2.800	1,386	5.993	41.32	"	
BIL-GR-5-9	"	"	1.000	0.1717	2.800	1,348	5.889	40.61	"	
						Average	6.123	42.22		
						Std. Dev.	0.230	1.58		
BIL-GR-5-2	45 min. @	22°C (72°F) (WET)	0.997	0.1741	2.800	1,107	4.783	32.98	5/25/89	
BIL-GR-5-4	107°C (225°F)	"	0.997	0.1704	2.800	1,028	4.538	31.29	"	
BIL-GR-5-6	"	"	0.996	0.1740	2.800	992	4.295	29.62	"	
BIL-GR-5-8	"	"	1.000	0.1740	2.800	1,093	4.713	32.49	"	
BIL-GR-5-10	"	"	0.996	0.1681	2.800	977	4.376	30.17	"	
						Average	4.541	31.31		
						Std. Dev.	0.210	1.44		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
(2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.3

INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 30 MINUTES AT 93°C (200°F)

Test : Apparent Interlaminar Shear (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp

Material : EA-9396 A/B; W133 Graphite Task #16 Tested By: TOB

Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thicknes (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GR-1-5	30 min. @	22°C (72°F) (DRY)	1.000	0.1809	2.800	1,526	6.325	43.61	1/23/89	
BIL-GR-1-9	93°C (200°F)	"	0.998	0.1759	2.800	1,420	6.065	41.82	"	
BIL-GR-1-14	"	"	0.998	0.1807	2.800	1,508	6.271	43.24	"	
						Average	6.220	42.89		
						Std. Dev.	0.137	0.94		
BIL-GR-1-1	30 min. @	22°C (72°F) (WET)	1.001	0.1758	2.816	1,089	4.640	32.00	4/24/89	
BIL-GR-1-7	93°C (200°F)	"	1.001	0.1804	2.816	1,027	4.266	29.41	"	
BIL-GR-1-16	"	"	1.000	0.1793	2.816	1,051	4.396	30.31	"	
						Average	4.434	30.57		
						Std. Dev.	0.190	1.31		
BIL-GR-1-4	30 min. @	93°C (200°F) (WET)	1.001	0.1802	2.816	539	2.241	15.45	4/25/89	
BIL-GR-1-10	93°C (200°F)	"	0.999	0.1770	2.816	533	2.262	15.59	"	
BIL-GR-1-13	"	"	0.999	0.1804	2.816	557	2.319	15.99	"	
						Average	2.274	15.68		
						Std. Dev.	0.040	0.28		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
(2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.4

INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 30 MINUTES AT 82°C (180°F)

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation: Warp			
Material :	EA-9396 A/B; W133 Graphite				Task #16			Tested By:		
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-H7-5-ILS-5	30 min. @	22°C (72°F) (DRY)	0.500	0.1700	2.765	760	6.706	46.24	2/16/88	
BIL-H7-5-ILS-14	82°C (180°F)	"	0.500	0.1720	2.765	688	6.000	41.37	"	
BIL-H7-5-ILS-25	"	"	0.502	0.1680	2.765	674	5.994	41.33	"	
						Average	6.233	42.98		
						Std. Dev.	0.409	2.82		
BIL-H7-5-ILS-8	30 min. @	22°C (72°F) (WET)	0.499	0.1730	2.765	504	4.379	30.19	3/9/88	
BIL-H7-5-ILS-17	82°C (180°F)	"	0.498	0.1730	2.765	472	4.109	28.33	"	
BIL-H7-5-ILS-21	"	"	0.501	0.1720	2.765	520	4.526	31.21	"	
						Average	4.338	29.91		
						Std. Dev.	0.211	1.46		
BIL-H7-5-ILS-3	30 min. @	93°C (200°F) (WET)	0.501	0.1690	2.765	205	1.816	12.52	3/9/88	
BIL-H7-5-ILS-9	82°C (180°F)	"	0.499	0.1720	2.765	233	2.036	14.04	"	
BIL-H7-5-ILS-19	"	"	0.499	0.1720	2.765	212	1.853	12.77	"	
						Average	1.901	13.11		
						Std. Dev.	0.118	0.81		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
(2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.5

INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 45 MINUTES AT 79°C (175°F)

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)					Specimen Orientation: Warp		
Material :	EA-9396 A/B; W133 Graphite				Task #16			Tested By:		TOB
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thicknes (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-4(R)-1	45 min. @	22°C (72°F) (DRY)	0.996	0.1746	2.800	1,270	5.477	37.77	1/23/89	
BIL-GR-4(R)-3	79°C (175°F)	"	0.995	0.1723	2.800	1,354	5.925	40.85	"	
BIL-GR-4(R)-5	"	"	0.996	0.1659	2.800	1,230	5.584	38.50	"	
BIL-GR-4(R)-7	"	"	0.997	0.1757	2.800	1,310	5.606	38.66	"	
BIL-GR-4(R)-9	"	"	0.996	0.1732	2.800	1,287	5.596	38.58	"	
						Average	5.638	38.87		
						Std. Dev.	0.169	1.16		
BIL-GR-4(R)-2	45 min. @	22°C (72°F) (WET)	0.998	0.1741	2.800	962	4.153	28.63	5/25/89	
BIL-GR-4(R)-4	79°C (175°F)	"	0.997	0.1712	2.800	937	4.119	28.40	"	
BIL-GR-4(R)-6	"	"	0.997	0.1763	2.800	933	3.983	27.46	"	
BIL-GR-4(R)-8	"	"	0.998	0.1740	2.800	930	4.019	27.71	"	
BIL-GR-4(R)-10	"	"	0.997	0.1675	2.800	849	3.813	26.29	"	
						Average	4.017	27.70		
						Std. Dev.	0.134	0.92		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
(2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.6

INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 7 DAYS AT 22°C (72°F)

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)					Specimen Orientation: Warp		
Material :	EA-9396 A/B; W133 Graphite				Task #16			Tested By:		TOB
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thicknes (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-20-1	7 days @	22°C (72°F) (DRY)	1.004	0.1814	2.816	979	4.031	27.79	5/25/89	
BIL-GR-20-4	22°C (72°F) plus	"	1.005	0.1753	2.816	1,216	5.179	35.71	"	
BIL-GR-20-5	additional 3 mos.	"	1.004	0.1728	2.816	1,227	5.306	36.59	"	
BIL-GR-20-8	dry storage or	"	1.005	0.1760	2.816	1,196	5.074	34.98	"	
BIL-GR-20-9	wet-aging (Note 3)	"	1.005	0.1771	2.816	1,117	4.708	32.46	"	
BIL-GR-20-12	"	"	1.005	0.1758	2.816	1,222	5.188	35.77	"	
BIL-GR-20-13	"	"	1.005	0.1735	2.816	1,282	5.515	38.03	"	
BIL-GR-20-16	"	"	0.998	0.1730	2.816	1,167	5.071	34.97	"	
						Average	5.009	34.54		
						Std. Dev.	0.457	3.15		
BIL-GR-20-3	7 days @	22°C (72°F) (WET)	1.004	0.1747	2.816	823	3.519	24.26	5/25/89	
BIL-GR-20-7	22°C (72°F) plus	"	1.005	0.1728	2.816	880	3.804	26.23	"	
BIL-GR-20-11	additional 3 mos.	"	1.005	0.1797	2.816	734	3.050	21.03	"	
BIL-GR-20-15	dry storage or	"	1.005	0.1741	2.816	814	3.491	24.07	"	
BIL-GR-20-17	wet-aging (Note 3)	"	1.004	0.1761	2.816	749	3.176	21.90	"	
						Average	3.408	23.50		
						Std. Dev.	0.299	2.06		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
(2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.
(3) Vacuum pressure was applied only during first four hours of cure.

APPENDIX K

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR STRENGTH, EFFECT OF EXPOSURE TO 177°C (350°F)

The two tables in this appendix present the detailed interlaminar shear strength data for specimens exposed to 177°C (350°F). A summary of these data was presented and discussed in Section 3.12.1.

TABLE K.1

EFFECT OF ELEVATED TEMPERATURE EXPOSURE ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)					Specimen Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #1	Task #8				Tested By:		TOB & DH
Specimen Number	Exposure Condition	Test Conditions (3)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GL-13(R)-6	2 hrs. @	22°C (72°F) (DRY)	1.002	0.1334	1.063	986	5.528	38.12	NA	4/19/89	(1)
BIL-GL-13(R)-16	177°C (350°F)	"	0.999	0.1322	1.063	951	5.397	37.21	NA	"	(1)
BIL-GL-13(R)-38	"	"	1.000	0.1352	1.063	1,084	6.016	41.48	NA	"	(1)
						Average	5.647	38.94			
						Std. Dev.	0.326	2.25			
BIL-GL-13(R)-8	2 hrs. @	93°C (200°F) (WET)	1.001	0.1352	1.080	326	1.807	12.46	1.98	10/30/89	(1)
BIL-GL-13(R)-18	177°C (350°F)	"	1.005	0.1329	1.080	350	1.965	13.55	2.04	"	(1)
BIL-GL-13(R)-40	"	"	1.002	0.1365	1.080	370	2.029	13.99	2.10	"	(1)
						Average	1.934	13.33	2.04		
						Std. Dev.	0.114	0.79	0.06		
BIL-GL-13(R)-7	16 hrs. @	22°C (72°F) (DRY)	1.001	0.1329	1.063	1,038	5.850	40.34	NA	4/19/89	(2)
BIL-GL-13(R)-17	177°C (350°F)	"	1.002	0.1349	1.063	1,079	5.985	41.27	NA	"	(2)
BIL-GL-13(R)-39	(Note 4)	"	1.000	0.1373	1.063	1,135	6.201	42.76	NA	"	(2)
						Average	6.012	41.45			
						Std. Dev.	0.177	1.22			
BIL-GL-13(R)-9	16 hrs. @	93°C (200°F) (WET)	1.000	0.1316	1.080	314	1.790	12.34	2.20	10/30/89	(2)
BIL-GL-13(R)-19	177°C (350°F)	"	1.001	0.1326	1.080	336	1.899	13.09	2.27	"	(2)
BIL-GL-13(R)-41	(Note 4)	"	1.001	0.1369	1.080	381	2.085	14.38	2.29	"	(2)
						Average	1.924	13.27	2.25		
						Std. Dev.	0.150	1.03	0.05		

(1) Specimens turned slightly brown as result of exposure.

(2) Specimens turned dark brown as result of exposure.

(3) Wet = wet-aging at 60°C (140°F)/95-100% R.H. until saturated.

(4) Three segments of 6+6+4 hours.

TABLE K.2

EFFECT OF ELEVATED TEMPERATURE EXPOSURE ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #8				Tested By:	TOB & DH

Specimen Number	Exposure Condition	Test Conditions (1)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-17-6	2 hrs. @	22°C (72°F) (DRY)	1.000	0.1819	2.816	1,220	5.028	34.67	NA	4/19/89	
BIL-GR-17-16	177°C (350°F)	"	1.003	0.1752	2.816	1,119	4.776	32.93	NA	"	
BIL-GR-17-38	"	"	1.000	0.1726	2.816	1,197	5.201	35.86	NA	"	
						Average	5.002	34.49			
						Std. Dev.	0.214	1.47			
BIL-GR-17-8	2 hrs. @	93°C (200°F) (WET)	1.001	0.1825	2.846	510	2.094	14.44	2.42	12/7/89	
BIL-GR-17-18	177°C (350°F)	"	1.002	0.1829	2.846	453	1.854	12.78	2.49	"	
BIL-GR-17-40	"	"	1.002	0.1742	2.846	471	2.024	13.95	2.15	"	
						Average	1.990	13.72	2.35		
						Std. Dev.	0.123	0.85	0.18		
BIL-GR-17-7	16 hrs. @	22°C (72°F) (DRY)	1.003	0.1802	2.816	1,244	5.163	35.60	NA	4/19/89	
BIL-GR-17-17	177°C (350°F)	"	1.000	0.1829	2.816	1,343	5.507	37.97	NA	"	
BIL-GR-17-39	(Note 2)	"	0.999	0.1731	2.816	1,177	5.107	35.21	NA	"	
						Average	5.259	36.26			
						Std. Dev.	0.216	1.49			
BIL-GR-17-9	16 hrs. @	93°C (200°F) (WET)	1.000	0.1770	2.846	438	1.856	12.80	2.31	12/7/89	
BIL-GR-17-19	177°C (350°F)	"	1.002	0.1851	2.846	454	1.836	12.66	2.49	"	
BIL-GR-17-41	(Note 2)	"	1.002	0.1762	2.846	484	2.056	14.18	2.24	"	
						Average	1.916	13.21	2.35		
						Std. Dev.	0.122	0.84	0.13		

(1) Wet = wet-aging at 60°C (140°F)/95-100% R.H. until saturated.

(2) Three segments of 6+6+4 hours.

APPENDIX L
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR STRENGTH, EFFECT OF RESIN/FIBER CONTENT

The 12 tables in this appendix present the detailed interlaminar shear strength data for specimens prepared with nonstandard fiber contents. All of the laminates from which these specimens were machined were cured in accordance with the baseline cure schedule. The reduced fiber contents were achieved by varying the resin/reinforcement ratios during impregnation and the bleeder ratio during bagging. The laminate preparation details were described in Appendix B.3. A summary of these data was presented and discussed in Section 3.8.

TABLE L.1

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass			Batch #4 Task #12			Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GL-31-1	22°C (72°F) (DRY)	1.002	0.1387	1.100	981	5.295	36.51	NA	10/30/89	(1)
BIL-GL-31-3	"	1.002	0.1327	1.100	943	5.320	36.68	NA	"	(1)
BIL-GL-31-5	"	1.000	0.1398	1.100	979	5.250	36.20	NA	"	(1)
					Average	5.288	36.46			
					Std. Dev.	0.035	0.24			
BIL-GL-31-2	22°C (72°F) (WET)	1.002	0.1339	1.069	532	2.974	20.50	1.88	10/30/89	(1,2)
BIL-GL-31-4	"	1.002	0.1324	1.069	575	3.251	22.41	1.87	"	(1,2)
					Average	3.112	21.46	1.87		
					Std. Dev.	0 196	1.35	0.00		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 55.4
Resin Content (wt. %) = 26.2
Void content (vol. %) = 5.0
Specific Gravity = 1.94

(2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.2

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass			Batch #4 Task #12			Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GL-30-1	22°C (72°F) (DRY)	1.003	0.1397	1.080	1,018	5.449	37.57	NA	10/30/89	(1)
BIL-GL-30-3	"	1.002	0.1312	1.080	973	5.551	38.27	NA	"	(1)
BIL-GL-30-5	"	1.003	0.1392	1.080	1,044	5.608	38.67	NA	"	(1)
					Average	5.536	38.17			
					Std. Dev.	0.081	0.56			
BIL-GL-30-2	22°C (72°F) (WET)	1.002	0.1337	1.069	570	3.191	22.00	1.88	1/22/90	(1,2)
BIL-GL-30-4	"	1.003	0.1345	1.069	570	3.169	21.85	1.85	"	(1,2)
					Average	3.180	21.93	1.86		
					Std. Dev.	0.016	0.11	0.02		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 54.3
Resin Content (wt. %) = 26.7
Void content (vol. %) = 6.1
Specific Gravity = 1.89

(2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.3

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)				Specimen Orientation:		Warp
Material :	EA-9396 A/B; 7781 Glass		Batch #4 Task #12				Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GL-33-1	22°C (72°F) (DRY)	1.001	0.1756	1.462	1,126	4.804	33.13	NA	10/30/89	(1)
BIL-GL-33-3	"	1.001	0.1378	1.100	1,042	5.666	39.06	NA	"	(1)
BIL-GL-33-5	"	1.001	0.1382	1.100	1,108	6.007	41.42	NA	"	(1)
					Average	5.492	37.87			
					Std. Dev.	0.620	4.27			
BIL-GL-33-2	22°C (72°F) (WET)	1.001	0.1456	1.206	476	2.449	16.89	2.17	1/22/90	(1,2)
BIL-GL-33-4	"	1.000	0.1413	1.206	659	3.498	24.12	2.09	"	(1,2)
					Average	2.974	20.50	2.13		
					Std. Dev.	0.741	5.11	0.06		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 52.3
Resin Content (wt. %) = 28.4
Void content (vol. %) = 6.4
Specific Gravity = 1.86

(2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.4

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent interlaminar shear	(4pt loading at 1/4 pts. L/D = 8/1)	Specimen Orientation: Warp
Material :	EA-9396 A/B; 7781 Glass	Batch #4 Task #12	Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GL-10-21	22°C (72°F) (DRY)	1.000	0.1605	1.286	1,206	5.636	38.86	5/26/89	(1)
BIL-GL-10-22	"	0.998	0.1616	1.286	1,174	5.460	37.64	"	(1)
BIL-GL-10-23	"	0.997	0.1622	1.286	1,155	5.357	36.93	"	(1)
BIL-GL-10-24	"	0.997	0.1587	1.286	1,167	5.532	38.14	"	(1)
					Average	5.496	37.89		
					Std. Dev.	0.118	0.81		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 45.6
Resin Content (wt. %) = 35.2
Void Content (vol. %) = 4.7
Specific Gravity = 1.79

TABLE L.5

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:	Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #5 Task #12			Tested By:	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-54-2	22°C (72°F) (DRY)	0.998	0.1788	1.600	1,098	4.617	31.83	10/7/91	(1)
BIL-GL-54-6	"	0.999	0.1997	1.600	1,253	4.709	32.47	"	(1)
BIL-GL-54-8	"	0.999	0.2064	1.600	1,407	5.116	35.28	"	(1)
					Average	4.814	33.19		
					Std. Dev.	0.266	1.83		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 35.8
Resin Content (wt. %) = 43.6
Void content (vol. %) = 8.8
Specific Gravity = 1.62

TABLE L.6

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:			Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #5 Task #12			Tested By:			DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-53-6	22°C (72°F) (DRY)	0.999	0.2218	1.600	1,521	5.150	35.51	10/7/91	(1)
BIL-GL-53-8	"	0.998	0.2252	1.600	1,473	4.915	33.89	"	(1)
					Average	5.033	34.70		
					Std. Dev.	0.166	1.15		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 33.9
Resin Content (wt. %) = 45.6
Void content (vol. %) = 9.3
Specific Gravity = 1.59

TABLE L.7

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation:		Warp
Material :	EA-9396 A/B: W133 Graphite		Batch #4 Task #12				Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-51-1	22°C (72°F) (DRY)	1.002	0.1721	2.769	1.348	5.863	40.42	NA	11/1/89	(1)
BIL-GR-51-3	"	1.002	0.1746	2.789	1.401	6.006	41.41	NA	"	(1)
BIL-GR-51-5	"	1.001	0.1733	2.769	1.325	5.729	39.50	NA	"	(1)
					Average	5.866	40.44			
					Std Dev.	0.139	0.96			
BIL-GR-51-2	22°C (72°F) (WET)	1.001	0.1742	2.832	990	4.258	29.36	2.32	2/23/90	(1,2)
BIL-GR-51-4	"	1.002	0.1753	2.832	1.009	4.308	29.71	2.29	"	(1,2)
					Average	4.283	29.53	2.30		
					Std. Dev.	0.035	0.24	0.02		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 55.8
Resin Content (wt. %) = 32.5
Void content (vol. %) = 6.5
Specific Gravity = 1.47

(2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.8

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 16/1)			Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #4 Task #12			Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-52-1	22°C (72°F) (DRY)	1.001	0.1714	2.789	1,231	5.381	37.10	NA	11/1/89	(1)
BIL-GR-52-3	"	1.002	0.1791	2.789	1,492	6.235	42.99	NA	"	(1)
BIL-GR-52-5	"	1.002	0.1757	2.789	1,397	5.951	41.03	NA	"	(1)
					Average	5.856	40.38			
					Std. Dev.	0.435	3.00			
BIL-GR-52-2	22°C (72°F) (WET)	1.002	0.1778	2.832	1,099	4.627	31.90	2.29	2/23/90	(1,2)
BIL-GR-52-4	"	1.002	0.1773	2.832	1,149	4.851	33.45	2.29	"	(1,2)
					Average	4.739	32.67	2.29		
					Std. Dev.	0.158	1.09	0.00		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 54.7
Resin Content (wt. %) = 33.6
Void content (vol. %) = 6.4
Specific Gravity = 1.47

(2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.9

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 16/1)			Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #4 Task #12			Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-53-1	22°C (72°F) (DRY)	1.001	0.1826	3.017	1,509	6.192	42.69	NA	11/1/89	(1)
BIL-GR-53-3	"	1.001	0.1957	3.017	1,615	6.183	42.63	NA	"	(1)
BIL-GR-53-5	"	1.001	0.1865	3.017	1,640	6.589	45.43	NA	"	(1)
					Average	6.321	43.58			
					Std. Dev.	0.232	1.60			
BIL-GR-53-2	22°C (72°F) (WET)	1.000	0.1866	3.033	1,185	4.763	32.84	2.58	2/23/90	(1,2)
BIL-GR-53-4	"	1.002	0.1895	3.033	1,305	5.155	35.54	2.62	"	(1,2)
					Average	4.959	34.19	2.60		
					Std. Dev.	0.277	1.91	0.03		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 50.1
Resin Content (wt. %) = 39.0
Void content (vol. %) = 4.9
Specific Gravity = 1.46

(2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.10

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 16/1)			Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #4 Task #12			Tested By:		DH & PM
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-54-1	22°C (72°F) (DRY)	0.999	0.1853	3.017	1,561	6.324	43.61	NA	11/1/89	(1)
BIL-GR-54-3	"	1.000	0.1931	3.017	1,684	6.541	45.10	NA	"	(1)
BIL-GR-54-5	"	1.000	0.1883	3.017	1,549	6.170	42.54	NA	"	(1)
					Average	6.345	43.75			
					Std. Dev.	0.186	1.28			
BIL-GR-54-2	22°C (72°F) (WET)	1.001	0.1901	3.033	1,300	5.124	35.33	2.73	2/23/90	(1,2)
BIL-GR-54-4	"	1.001	0.1921	3.033	1,311	5.113	35.26	2.72	"	(1,2)
					Average	5.119	35.29	2.72		
					Std. Dev.	0.007	0.05	0.00		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 49.8
Resin Content (wt. %) = 39.0
Void content (vol. %) = 4.7
Specific Gravity = 1.47

(2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.11

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 12/1)			Specimen Orientation:			Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #5 Task #12			Tested By:			DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-84-2	22°C (72°F) (DRY)	1.004	0.2329	2.920	1,446	4.638	31.98	10/7/91	(1)
BIL-GR-84-6	"	1.003	0.2402	2.920	1,450	4.513	31.12	"	(1)
BIL-GR-84-8	"	1.003	0.2394	2.920	1,442	4.503	31.05	"	(1)
					Average	4.552	31.38		
					Std. Dev.	0.075	0.52		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 42.3
Resin Content (wt. %) = 45.6
Void content (vol. %) = 7.5
Specific Gravity = 1.39

TABLE L.12

EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 12/1)	Specimen Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite	Batch #5 Task #12	Tested By:	DRB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GR-79-2	22°C (72°F) (DRY)	1.001	0.2433	2.920	1,690	5.206	35.90	10/7/91	(1)
BIL-GR-79-6	"	0.999	0.2572	2.920	1,668	4.868	33.57	"	(1)
BIL-GR-79-8	"	1.002	0.2582	2.920	1,555	4.509	31.09	"	(1)
					Average	4.861	33.52		
					Std. Dev.	0.349	2.40		

Remarks:

(1) Physical Properties:
Fiber Content (vol. %) = 40.5
Resin Content (wt. %) = 48.8
Void content (vol. %) = 5.5
Specific Gravity = 1.41

TABLE L.13

EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:			Fill
Material :	EA-9396 A/B; 7781 Glass			Batch #5	Task #12		Tested By:			DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-53-1	72°F (DRY)	0.998	0.2124	5,945	28.05	2.425	12,312		11/15/90	(1b,3,4)
BIL-GL-53-3	"	0.998	0.2043	7,114	34.69	2.426	13,879	0.142	11/16/90	(1b,3,4)
BIL-GL-53-5	"	0.998	0.2141	7,351	34.40	2.349	15,535		11/15/90	(1a,3,4)
BIL-GL-53-7	"	0.999	0.1873	7,444	39.80	2.758	14,927		"	(1b,3,4)
BIL-GL-53-9	"	0.998	0.2184	7,915	36.30	2.375	14,209	0.082	11/16/90	(1b,3,4)
BIL-GL-53-11	"	0.999	0.2007	6,746	33.66	2.493	13,535		11/15/90	(1b,3,4)
				Average	34.52	2.471	14,066	0.112		
				Std. Dev.	3.84	0.149	1,124	0.042		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
   (a) Shear crimping
   (b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Physical Properties:
   Fiber Content (vol. %) = 33.9
   Resin Content (wt. %) = 45.6
   Void Content (vol. %) = 9.3
   Specific Gravity = 1.59

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
193.4	16.72	12,312
240.6	16.73	13,879
237.2	16.20	15,535
274.4	19.02	14,927
250.3	16.37	14,209
232.1	17.19	13,535
Average 238.0	17.04	14,066
Std. Dev. 26.5	1.03	1,124

TABLE L.14

EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GLASS REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781 Glass		Batch #5	Task #12			Tested By:		DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-54-1	72°F (DRY)	0.998	0.1806	6,587	36.56	2.447	14,634		11/13/90	(1a,3,4)
BIL-GL-54-3	"	0.997	0.1847	6,868	37.29	2.901	15,828	0.181	11/14/90	(1a,3,4)
BIL-GL-54-5	"	0.998	0.1966	7,549	38.47	2.403	17,849		11/13/90	(1b,3,4)
BIL-GL-54-7	"	0.992	0.2050	7,515	36.95	2.656	17,007		"	(1b,3,4)
BIL-GL-54-9	"	0.998	0.2032	7,136	35.19	2.860	15,857	0.158	11/14/90	(1a,3,4)
BIL-GL-54-11	"	0.991	0.1892	6,873	36.65	2.989	12,173		11/13/90	(1a,3,4)
				Average	36.85	2.709	15,558	0.170		
				Std. Dev.	1.07	0.246	1,991	0.017		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (a) Shear crimping
  (b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Physical Properties:
  Fiber Content (vol. %) = 35.8
  Resin Content (wt. %) = 43.6
  Void Content (vol. %) = 8.8
  Specific Gravity = 1.62

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
	252.1	16.87	14,634
	257.1	20.01	15,828
	265.3	16.57	17,849
	254.8	18.31	17,007
	242.6	19.72	15,857
	252.7	20.61	12,173
Average	254.1	18.68	15,558
Std. Dev.	7.4	1.70	1,991

TABLE L.15

EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:			Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #5	Task #12			Tested By:			DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-79-1	72°F (DRY)	0.997	0.2335	10,835	46.53	5.470	10,557		11/16/90	(1a,3,4)
BIL-GR-79-3	"	1.001	0.2519	11,738	46.57	5.751	7,860	0.021	11/19/90	(1a,3,4)
BIL-GR-79-5	"	0.995	0.2565	11,201	43.90	4.252	12,340		11/16/90	(1a,3,4)
BIL-GR-79-7	"	1.001	0.2615	11,118	42.47	5.549	7,490		"	(1a,3,4)
BIL-GR-79-9	"	0.999	0.2507	9,038	36.09	5.388	6,800	0.213	11/19/90	(1a,3,4)
BIL-GR-79-11	"	1.000	0.2322	12,456	53.64	6.036	9,106		11/16/90	(1a,3,4)
				Average	44.87	5.408	9,026	0.117		
				Std. Dev.	5.77	0.612	2,098	0.136		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (a) Shear crimping
  (b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Physical Properties:
  Fiber Content (vol. %) = 40.5
  Resin Content (wt. %) = 48.8
  Void Content (vol. %) = 5.5
  Specific Gravity = 1.41

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
320.8	37.72	10,557
321.1	39.66	7,860
302.7	29.32	12,340
292.8	38.26	7,490
248.8	37.15	6,800
369.9	41.62	9,106
Average 309.4	37.29	9,026
Std. Dev. 39.8	4.22	2,098

TABLE L.16

EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GRAPHITE REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:			Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #5	Task #12			Tested By:			DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-84-1	72°F (DRY)	1.002	0.2254	11,357	50.30	6.101	8,945		11/20/90	(1a,3,4)
BIL-GR-84-3	"	1.003	0.2395	10,933	45.49	5.687	9,473	0.037	"	(1b,3,4)
BIL-GR-84-5	"	1.003	0.2458	10,900	44.19	5.599	6,533		11/19/90	(1b,3,4)
BIL-GR-84-7	"	1.003	0.2435	8,975	36.75	4.665	7,647		"	(1a,3,4)
BIL-GR-84-9	"	1.004	0.2460	10,854	43.97	5.378	8,042	0.007	11/20/90	(1a,3,4)
BIL-GR-84-11	"	1.004	0.2309	8,901	38.40	5.276	7,500		11/19/90	(1b,3,4)
				Average	43.18	5.451	8,023	0.022		
				Std. Dev.	4.94	0.480	1,057	0.021		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
  (a) Shear crimping
  (b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Physical Properties:
  Fiber Content (vol. %) = 42.3
  Resin Content (wt. %) = 45.6
  Void Content (vol. %) = 7.5
  Specific Gravity = 1.39

SI Conversion		
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
346.8	42.06	8,945
313.7	39.21	9,473
304.7	38.60	6,533
253.4	32.16	7,647
303.2	37.08	8,042
264.7	36.38	7,500
Average 297.8	37.58	8,023
Std. Dev. 34.0	3.31	1,057

APPENDIX M
INDIVIDUAL SPECIMEN PROPERTIES, EFFECT OF STORAGE TIME AND TEMPERATURE

The tables and figures in this appendix present the detailed mechanical, physical, thermophysical, and chemical property data measured during this program. The data include HPLC spectra, viscosity measurements on both parts A and B, DSC analyses, FTIR spectra, Rheometrics viscosity profiles, and interlaminar shear strengths. Each of these specific types of data are presented separately in sections M.1 through M.6 of this appendix. These data are summarized in Section 3.7.

M.1 HPLC SPECTRA

Figures M.1 through M.6 present the HPLC spectra obtained during the program. It can be seen from Figures M.1(b) that part B of the EA9396 resin system produced no significant features. As a result, no further HPLC tests were performed on part B. Table M.1 summarizes the pertinent features and test parameters for each of the tests represented by Figures M.1 through M.6. It will be observed, both in Figures M.4 and M.6 as well as in Table M.1, that the retention times for the 12- and 24-month tests are about twice what .hey are in the other tests. This is due to the fact that the flow rate during the test was only half what it was in the other tests, thereby doubling the retention times.

In each case the test samples were prepared for analysis by making a 1% solution by weight in dioxane and filtering the solution through a 0.5-micron PTFE filter to remove insolubles.

M.2 BROOKFIELD VISCOSITY MEASUREMENTS

Viscosity measurements were made on both parts A and B of the EA9396 resin system using a Brookfield type RV Viscometer. This viscometer comes with a set of seven spindles to cover a wide range of viscosities. Spindle No. 7 was used for viscosity measurements of Part A, while Spindle No. 3 was used for Part B.

The samples that were tested were tested in the cans they were received in from Hysol. In the case of Part A, this was a quart can, while Part B was in a pint can. In each case the cans were not large enough to accommodate the spindle guard so this was removed during the viscosity measurements. While this is not in strict accordance with

the recommended procedure, since all of the tests were performed in the same way, the measurements do provide a consistent comparison of the material for each aging time from its initial receipt until the final measurement after 36 months of storage. In all cases the spindles were immersed to the recommended depths. Table M.2 lists the results of all the viscosity measurements made on both Parts A and B. These results were summarized and discussed in Section 3.7 (see Table 31 in particular).

M.3 HEAT OF REACTION TESTS (DSC)

Dynamic scanning calorimetric (DSC) tests were conducted on EA9396 in the as-received condition and after storage times of up to 24 months at various temperatures. From these tests the heat released during cure is obtained. Resin samples of approximately 5 mg were heated at a rate of 10°C (18°F)/min in these tests. Figures M.7 through M.22 present the DSC curves from each of these tests and the heat release during cure in these tests is tabulated in Table M.3.

If one considers only the heat release data for the 6-24 month storage times, there is a relatively consistent decrease in heat release as aging time increases and the decrease is greatest for the highest temperature storage condition.

M.4 FTIR SPECTRA

Figures M.23 through M.54 present the FTIR spectra obtained during the program. The tests were carried out using a Nicolet FTIR instrument. Spectra were obtained on both Parts A and B of the EA9396 resin system after storage times of up to 24 months at various temperatures. Samples were deposited on NaCl plates to perform the FTIR tests. No attempt has been made to interpret these spectra.

M.5 RHEOMETRIC VISCOSITY PROFILES

A Rheometrics Solids Analyzer (RSA-II) was used to measure the changing viscosity of EA9396 during cure. The test was carried out using approximately 0.1 gm samples in a parallel plate arrangement. The plates were positioned about 0.36 mm apart and oscillated at a frequency of 1 Hz. The motion of the plates was to slightly open and close in a tensile mode rather than to rotate with respect to one another in a torsional mode. The amount of motion represented a cyclic strain of 1.0% (±0.0036 mm) about the midpoint.

Both dynamic viscosity (η') and loss viscosity (η'') were measured in these tests. Since the dynamic viscosity is the most commonly used measure of material viscosity, only these charts are included in this section. Several points should be cited in regard to these data. First, the viscosity values plotted in the accompanying charts are not quantitative. The parallel plate arrangement was a novel way to use the RSA instrument. Normally the tests are carried out using a shear sandwich type arrangement. The low viscosity of the EA9396 system precluded use of the shear sandwich arrangement because the minimum gap setting was 0.5 mm and the material ran out of the fixture during the test. While the parallel plate approach was nonstandard, the viscosity vs. temperature curve was very similar to that obtained with the shear sandwich fixture. For this reason it is felt that so long as all of the tests were carried out in the same manner, comparisons of test results would be valid (i.e., temperatures at which minimum viscosity and gel occur). Second, due to compliance limitations of the RSA instrument, data recorded after gel are meaningless.

Figures M.55 through M.70 present the viscosity profiles obtained after various storage times up to 2 years and at storage temperatures up to 49°C (120°F). Pertinent features from these figures were listed in Table 29 of Section 3.7.

M.6 INTERLAMINAR SHEAR STRENGTH

Tables M.4-M.19 list the individual specimen interlaminar shear strength properties of laminates made with EA9396 resin that had been in storage for up to two years at temperatures up to 49°C (120°F). These data are summarized and discussed in Section 3.7 (Table 32 in particular).

TABLE M.1

HPLC TEST PARAMETERS AND RESULTS

Sample Age	Flow Rate (ml/min)	Solvent Gradient (1)	Retention Time (min.)		
			22°C (72°F) Storage	38°C (100°F) Storage	49°C (120°F) Storage
Initial	1.0	A	18.88	---	---
1 Month	1.0	A	---	18.48	18.44
6 Months	1.0	A	20.14	20.16	21.15
12 Months	0.5	A	39.24 (2)	37.68 (2)	37.92 (2)
18 Months	1.0	A	18.73	18.43	18.81
24 Months	0.5	B	40.87 (2)	41.22 (2)	41.36 (2)

NOTE:

(1) A:

Time	% Water	% Dioxane
0	00	50
10	50	50
40	30	70
50	30	70

B: 50% Water/50% Dioxane throughout test.

(2) These retention times are higher than the others by a factor of 2 because the flow rate during the test was half the flow rate in the other tests. This caused the retention times to be doubled. Thus, these test results are equivalent to those obtained for the other sample ages.

TABLE M.2

BROOKFIELD VISCOSITY MEASUREMENTS ON EA9396
AS A FUNCTION OF STORAGE TIME AT
VARIOUS TEMPERATURES

Date of Measurement	Storage Time(1)	Storage Temperature		Viscosity (Poise)	
		(°C)	(°F)	Part A	Part B
11/9/88	As received	N.A.		840	1
12/19/88	1 month	38	100	840	0.75
		49	120	880	0.75
2/9/89	3 months	22	72	920	1
5/16/89	6 months	22	72	720	1
7/20/89	8 months	38	100	840	1
		49	120	880	1
11/16/89	12 months	22	72	720	1
		38	100	960	1
		49	120	1000	1
5/16/90	18 months	22	72	1120	1
		38	100	1080	0.9
		49	120	2380	0.9
8/22/90	21 months	49	120	3440	0.75
11/17/90	24 months	22	72	820	1
		38	100	840	1
		49	120	6500	1
5/16/91	30 months	22	72	776	---
		38	100	2340	---
		49	120	>20,000(2)	---
11/15/91	36 months	22	72	800	---
		38	100	4600	---
6/15/92	43 months	22	72	1000	---
		38	100	>20,000 (2)	---
1/7/93	50 months	22	72	1000	---
		38	100	(3)	---

NOTES:

(1) Storage times are nominal, after receipt of material. Material was manufactured three months before receipt.

(2) This material was no longer processible into laminates and further storage was discontinued.

(3) Material had hard crust on surface.

TABLE M.3

EFFECT OF LONG-TERM STORAGE ON HEAT RELEASE DURING CURE

Storage Time	Heat Release During Cure (J/gm)			
	22°C (72°F) Storage	38°C (100°F) Storage	49°C (120°F) Storage	Average of All 3 Temperatures
1 Month	576.2	588.8	576.4	580.5
3 Months	572.9			
6 Months	633.8	593.5	624.6	617.3
12 Months	613.4	589.5	601.6	601.5
18 Months	615.4	564.6	586.8	588.9
24 Months	599.6	575.6	560.6	578.6

TABLE M.4

EFFECT OF RESIN STORAGE FOR 1 MONTH AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation:			Warp
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #13			Tested By:			DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-6-1	1 month @ 22°C (72°F)	(DRY)	0.996	0.1662	2.800	1,182	5.354	36.92	NA	1/22/89	
BIL-GR-6-3	22°C (72°F)	"	0.997	0.1711	2.800	1,258	5.530	38.13	NA	"	
BIL-GR-6-5	"	"	0.993	0.1664	2.800	1,160	5.265	36.30	NA	"	
						Average	5.383	37.12			
						Std. Dev.	0.135	0.93			
BIL-GR-6-2	1 month @ 22°C (72°F)	(WET)	0.999	0.1687	2.800	810	3.606	24.86	3.86	4/24/89	(1)
BIL-GR-6-4	22°C (72°F)	"	0.998	0.1691	2.800	855	3.801	26.21	3.96		(1)
						Average	3.704	25.54	3.91		
						Std. Dev.	0.138	0.95	0.07		

(1) Specimens aged by water immersion 140°F.

TABLE M.5

EFFECT OF RESIN STORAGE FOR 1 MONTH AT 38°C (100°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-2-1	1 month @	22°C (72°F) (DRY)	1.003	0.1683	2.800	1,380	6.131	42.28	NA	1/22/89	
BIL-GR-2-3	38°C (100°F)	"	1.001	0.1741	2.800	1,438	6.186	42.65	NA	"	
BIL-GR-2-5	"	"	1.002	0.1695	2.800	1,400	6.180	42.61	NA	"	
						Average	6.166	42.51			
						Std. Dev.	0.030	0.21			
BIL-GR-2-2	1 month @	22°C (72°F) (WET)	0.998	0.1709	2.816	1,078	4.742	32.69	2.71	4/24/89	(1)
BIL-GR-2-4	38°C (100°F)	"	0.998	0.1724	2.816	1,099	4.790	33.03	2.69	"	(1)
						Average	4.766	32.86	2.70		
						Std. Dev.	0.034	0.24	0.01		

(1) Specimens aged by water immersion @ 140°F.

TABLE M.6

EFFECT OF RESIN STORAGE FOR 1 MONTH AT 49°C (120°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-3-1	1 month @	22°C (72°F) (DRY)	0.983	0.1727	2.800	1,267	5.597	38.59	NA	1/23/89	
BIL-GR-3-3	49°C (120°F)	"	0.983	0.1760	2.800	1,332	5.774	39.81	NA	"	
BIL-GR-3-5	"	"	0.983	0.1745	2.800	1,309	5.723	39.46	NA	"	
						Average	5.698	39.29			
						Std. Dev.	0.091	0.63			
BIL-GR-3-2	1 month @	22°C (72°F) (WET)	0.983	0.1747	2.816	987	4.307	29.70	2.81	4/24/89	(1)
BIL-GR-3-4	49°C (120°F)	"	0.979	0.1764	2.816	1,001	4.347	29.97	3.00	"	(1)
						Average	4.327	29.84	2.91		
						Std. Dev.	0.028	0.19	0.13		

(1) Specimens aged by water immersion @ 140°F.

TABLE M.7

EFFECT OF RESIN STORAGE FOR 3 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #13					Tested By:		DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-30-1	3 mos. @	22°C (72°F) (DRY)	1.002	0.1660	2.678	1,246	5.617	38.73	NA	2/22/89	
BIL-GR-30-3	22°C (72°F)	"	1.003	0.1689	2.678	1,289	5.706	39.34	NA	"	
BIL-GR-30-5	"	"	1.002	0.1672	2.678	1,167	5.222	36.01	NA	"	
						Average	5.515	38.03			
						Std. Dev.	0.257	1.78			
BIL-GR-30-2	3 mos. @	22°C (72°F) (WET)	1.003	0.1683	2.816	999	4.441	30.62	1.53		(1)
BIL-GR-30-4	22°C (72°F)	"	1.003	0.1688	2.816	1,057	4.684	32.30	1.58		(1)
						Average	4.562	31.46	1.56		
						Std. Dev.	0.172	1.19	0.04		

(1) Specimens aged by water immersion @ 140°F.

TABLE M.8

EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		TOB & DH
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-49-1	6 mos. @	22°C (72°F) (DRY)	1.005	0.1888	2.816	1,499	5.928	40.87	NA	5/25/89	
BIL-GR-49-3	22°C (72°F)	"	1.005	0.1925	2.816	1,698	6.586	45.41	NA	"	
BIL-GR-49-5	"	"	1.005	0.1892	2.816	1,526	6.019	41.50	NA	"	
						Average	6.178	42.60			
						Std. Dev.	0.356	2.46			
BIL-GR-49-2	6 mos. @	22°C (72°F) (WET)	1.005	0.1975	3.159	1,159	4.379	30.20	2.66	12/12/89	(1)
BIL-GR-49-4	22°C (72°F)	"	1.005	0.1962	3.159	1,166	4.435	30.58	2.70	"	(1)
						Average	4.407	30.39	2.68		
						Std. Dev.	0.039	0.27	0.03		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.9

EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 38°C (100°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1 Task #13						Tested By:	TOB & DH
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-48-1	6 mos. @	22°C (72°F) (DRY)	1.006	0.1838	2.816	1,462	5.929	40.88	NA	5/25/89	
BIL-GR-48-3	38°C (100°F)	"	1.006	0.1994	2.816	1,591	5.950	41.02	NA	"	
BIL-GR-43-5	"	"	1.005	0.1818	2.816	1,639	6.727	46.38	NA	"	
						Average	6.202	42.76			
						Std. Dev.	0.455	3.13			
BIL-GR-48-2	6 mos. @	22°C (72°F) (WET)	1.005	0.1943	3.159	1,229	4.720	32.55	2.62	12/12/89	(1)
BIL-GR-48-4	38°C (100°F)	"	1.004	0.1974	3.159	1,230	4.655	32.09	2.60	"	(1)
						Average	4.687	32.32	2.61		
						Std. Dev.	0.046	0.32	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.10

EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 49°C (120°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		TOB & DH
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-47-1	6 mos. @	22°C (72°F) (DRY)	1.007	0.1873	2.816	1,559	6.199	42.74	NA	5/25/89	
BIL-GR-47-3	49°C (120°F)	"	1.007	0.1923	2.816	1,640	6.353	43.80	NA	"	
BIL-GR-47-5	"	"	1.006	0.1825	2.816	1,493	6.099	42.05	NA	"	
						Average	6.217	42.87			
						Std. Dev.	0.128	0.86			
BIL-GR-47-2	6 mos. @	22°C (72°F) (WET)	1.004	0.1975	3.159	1,128	4.266	29.42	2.79	12/12/89	(1)
BIL-GR-47-4	49°C (120°F)	"	1.005	0.2018	3.159	1,143	4.227	29.14	2.78	"	(1)
						Average	4.247	29.28	2.79		
						Std. Dev.	0.028	0.19	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.11

EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		DH
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-60-1	12 mos. @	22°C (72°F) (DRY)	0.998	0.1700	2.807	1,161	5.132	35.39	NA	5/25/89	
BIL-GR-60-3	22°C (72°F)	"	0.997	0.1791	2.807	1,324	5.561	38.34	NA	"	
BIL-GR-60-5	"	"	0.994	0.1762	2.807	1,257	5.383	37.11	NA	"	
						Average	5.359	36.95			
						Std. Dev.	0.215	1.49			
BIL-GR-60-2	12 mos. @	22°C (72°F) (WET)	0.997	0.1768	2.832	978	4.161	28.69	2.59	12/12/89	(1)
BIL-GR-60-4	22°C (72°F)	"	0.997	0.1773	2.832	1,066	4.523	31.19	2.59	"	(1)
						Average	4.342	29.94	2.59		
						Std. Dev.	0.256	1.76	0.00		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.12

EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 38°C (100°F) ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #13					Tested By:		DH
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-59-1	12 mos. @	22°C (72°F) (DRY)	0.998	0.1677	2.807	1,410	6.319	43.57	NA	12/6/89	
BIL-GR-59-3	38°C (100°F)	"	0.997	0.1768	2.807	1,482	6.306	43.48	NA	"	
BIL-GR-59-5	"	"	0.997	0.1727	2.807	1,468	6.394	44.09	NA	"	
						Average	6.340	43.71			
						Std. Dev.	0.048	0.33			
BIL-GR-59-2	12 mos. @	22°C (72°F) (WET)	0.998	0.1750	2.832	1,109	4.762	32.84	2.55	2/23/90	(1)
BIL-GR-59-4	38°C (100°F)	"	0.998	0.1761	2.832	1,111	4.741	32.69	2.54	"	(1)
						Average	4.752	32.76	2.54		
						Std. Dev.	0.015	0.10	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.13

EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 49°C (120°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #13				Tested By:		DH

Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-61-1	12 mos. @	22°C (72°F) (DRY)	0.996	0.1699	2.807	1,362	6.037	41.62	NA	12/6/89	
BIL-GR-61-3	49°C (120°F)	"	0.999	0.1810	2.807	1,469	6.093	42.01	NA	"	
BIL-GR-61-5	"	"	1.001	0.1754	2.807	1,491	6.369	43.91	NA	"	
						Average	6.166	42.52			
						Std. Dev.	0.178	1.23			
BIL-GR-61-2	12 mos. @	22°C (72°F) (WET)	0.996	0.1770	2.832	883	3.757	25.90	4.21	2/23/90	(1)
BIL-GR-61-4	49°C (120°F)	"	1.001	0.1801	2.832	915	3.807	26.25	4.29	"	(1)
						Average	3.782	26.07	4.25		
						Std. Dev.	0.035	0.24	0.05		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.14

EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		PM & DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-74-1	18 mos. @	22°C (72°F) (DRY)	1.000	0.1730	2.827	1,318	5.714	39.40	NA	6/12/90	
BIL-GR-74-3	22°C (72°F)	"	1.004	0.1820	2.827	1,590	6.526	45.00	NA	"	
BIL-GR-74-5	"	"	1.003	0.1770	2.827	1,450	6.126	42.24	NA	"	
						Average	6.122	42.21			
						Std. Dev.	0.406	2.80			
BIL-GR-74-2	18 mos. @	22°C (72°F) (WET)	1.002	0.1800	2.848	1,073	4.462	30.76	2.64	10/16/90	(1)
BIL-GR-74-4	22°C (72°F)	"	1.003	0.1800	2.848	1,152	4.786	33.00	2.66	"	(1)
						Average	4.624	31.88	2.65		
						Std. Dev.	0.229	1.58	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.15

EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 38°C (200°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		PM & DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-73-1	18 mos. @	22°C (72°F) (DRY)	1.000	0.1700	2.827	1,465	6.463	44.56	NA	6/12/90	
BIL-GR-73-3	38°C (100°F)	"	1.000	0.1850	2.827	1,545	6.264	43.19	NA	"	
BIL-GR-73-5	"	"	0.999	0.1730	2.827	1,510	6.553	45.18	NA	"	
						Average	6.427	44.31			
						Std. Dev.	0.148	1.02			
BIL-GR-73-2	18 mos. @	22°C (72°F) (WET)	1.000	0.1760	2.848	1,222	5.207	35.90	2.64	10/16/90	(1)
BIL-GR-73-4	38°C (100°F)	"	1.000	0.1760	2.848	1,215	5.178	35.70	2.66	"	(1)
						Average	5.192	35.80	2.65		
						Std. Dev.	0.021	0.15	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.16

EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 49°C (120°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		PM & DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlamina Shear Strer. (Ksi.)	(illegible)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-72-1	18 mos. @	22°C (72°F) (DRY)	0.999	0.1750	2.827	1,555	6.671	46.00	NA	6/12/90	
BIL-GR-72-3	49°C (120°F)	"	1.000	0.1800	2.827	1,605	6.688	46.11	NA	"	
BIL-GR-72-5	"	"	1.000	0.1750	2.827	1,595	6.836	47.13	NA	"	
						Average	6.731	46.41			
						Std. Dev.	0.091	0.63			
BIL-GR-72-2	18 mos. @	22°C (72°F) (WET)	0.995	0.1780	2.848	1,251	5.298	36.53	2.64	10/16/90	(1)
BIL-GR-72-4	49°C (120°F)	"	1.000	0.1770	2.848	1,190	5.042	34.77	2.66	"	(1)
						Average	5.170	35.65	2.65		
						Std. Dev.	0.180	1.24	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.17

EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-85-1	24 mos. @	22°C (72°F) (DRY)	1.002	0.1798	2.940	1,567	6.523	44.98	NA	1/4/91	
BIL-GR-85-3	22°C (72°F)	"	1.002	0.1821	2.940	1,650	6.782	46.76	NA	"	
BIL-GR-85-5	"	"	1.002	0.1738	2.940	1,587	6.835	47.13	NA	"	
						Average	6.713	46.29			
						Std. Dev.	0.167	1.15			
BIL-GR-85-2	24 mos. @	22°C (72°F) (WET)	1.002	0.1806	2.940	1,120	4.642	32.01	2.65	6/14/91	(1)
BIL-GR-85-4	22°C (72°F)	"	1 002	0.1790	2.940	1,110	4.642	32.00	2.62	"	(1)
						Average	4.642	32.00	2.63		
						Std. Dev.	0.000	0.00	0.02		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.18

EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 38°C (100°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite	Batch #1	Task #13				Tested By:		DRB

Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-86-1	24 mos. @	22°C (72°F) (DRY)	1.003	0.1845	2.940	1,520	6.160	42.48	NA	1/4/91	
BIL-GR-86-3	38°C (100°F)	"	1.002	0.1904	2.940	1,445	5.681	39.17	NA	"	
BIL-GR-86-5	"	"	1.002	0.1829	2.940	1,410	5.770	39.79	NA	"	
						Average	5.870	40.48			
						Std. Dev.	0.255	1.76			
BIL-GR-86-2	24 mos. @	22°C (72°F) (WET)	1.002	0.1885	2.940	1,060	4.209	29.02	2.80	6/14/91	(1)
BIL-GR-86-4	38°C (100°F)		1.002	0.1887	2.940	990	3.927	27.08	2.80	"	(1)
						Average	4.068	28.05	2.80		
						Std. Dev.	0.199	1.38	0.00		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.19

EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 49°C (120°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)						Specimen Orientation:		Warp
Material	EA-9396 A/B; W133 Graphite		Batch #1	Task #13					Tested By:		DRB
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-87-1	24 mos. @	22°C (72°F) (DRY)	1.004	0.1882	2.940	1,580	6.271	43.24	NA	1/4/91	
BIL-GR-87-3	49°C (120°F)	"	1.005	0.1861	2.940	1,595	6.396	44.10	NA	"	
BIL-GR-87-5	"	"	1.003	0.1798	2.940	1,465	6.093	42.01	NA	"	
						Average	6.253	43.12			
						Std. Dev.	0.152	1.05			
BIL-GR-87-2	24 mos. @	22°C (72°F) (WET)	1.005	0.1860	2.940	1,150	4.614	31.81	2.82	6/14/91	(1)
BIL-GR-87-4	49°C (120°F)	"	1.005	0.1856	2.940	1,130	4.544	31.33	2.84	"	(1)
						Average	4.579	31.57	2.83		
						Std. Dev.	0.050	0.34	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.20
EFFECT OF RESIN STORAGE FOR 43 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13				Tested By:		PM
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-89-1	43 mos. @	22°C (72°F) (DRY)	0.998	0.1632	2.685	1,446	6.659	45.91	NA	7/20/92	
BIL-GR-89-3	22°C (72°F)	"	1.001	0.1699	2.685	1,499	6.611	45.58	NA	"	
BIL-GR-89-5	"	"	1.001	0.1645	2.685	1,442	6.568	45.29	NA	"	
						Average	6.612	45.59			
						Std. Dev.	0.045	0.31			
BIL-GR-89-2	43 mos. @	22°C (72°F) (WET)	1.001	0.1648	2.690	1,080	4.910	33.86	2.87	2/19/93	(1)
BIL-GR-89-4	22°C (72°F)	"	0.999	0.1691	2.690	1,106	4.910	33.86	2.85	"	(1)
						Average	4.910	33.86	2.86		
						Std. Dev.	0.000	0.00	0.01		

(1) Specimens aged by water immersion at 140°F.

TABLE M.21

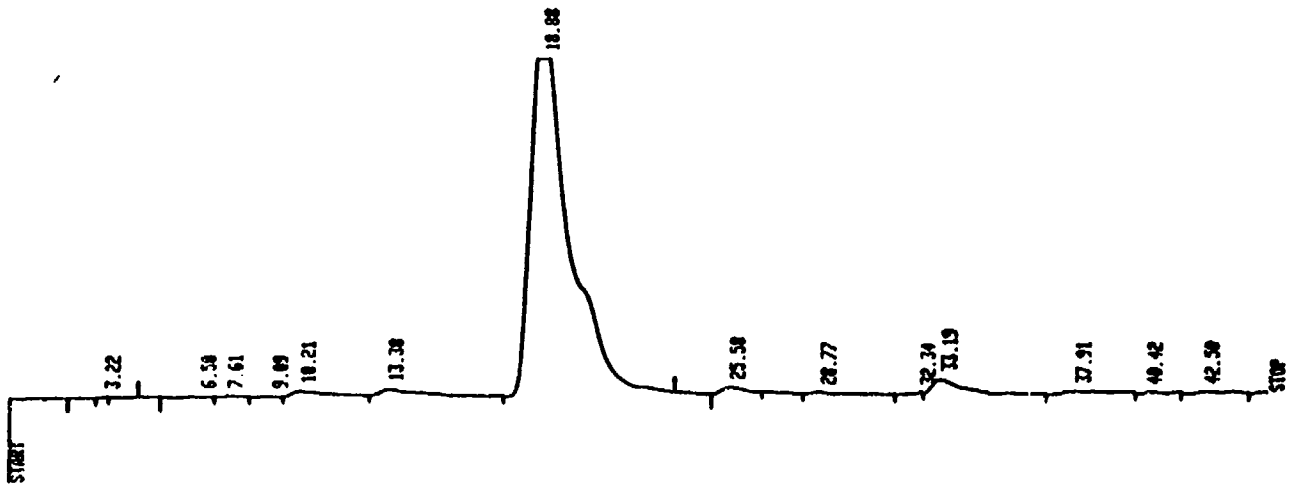
EFFECT OF RESIN STORAGE FOR 43 MONTHS AT 38°C (100°F) ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:		Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1 Task #13					Tested By:		PM
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-90-1	43 mos. @	22°C (72°F) (DRY)	1.001	0.1683	2.685	1,479	6.584	45.40	NA	7/20/92	
BIL-GR-90-3	38°C (100°F)	"	1.000	0.1709	2.685	1,497	6.570	45.30	NA	"	
BIL-GR-90-5	"	"	1.000	0.1698	2.685	1,513	6.683	46.08	NA	"	
						Average	6.612	45.59			
						Std. Dev.	0.062	0.42			
BIL-GR-90-2	43 mos. @	22°C (72°F) (WET)	1.001	0.1720	2.690	1,146	4.992	34.42	3.08	2/19/93	(1)
BIL-GR-90-4	38°C (100°F)	"	1.001	0.1705	2.690	1,074	4.720	32.54	2.95	"	(1)
						Average	4.856	33.48	3.02		
						Std. Dev.	0.193	1.33	0.09		

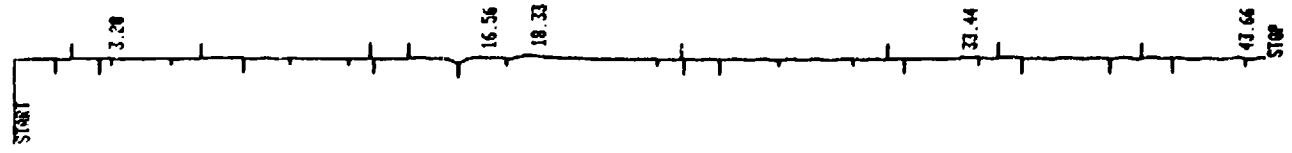
(1) Specimens aged by water immersion at 140°F.

TABLE M.22
EFFECT OF RESIN STORAGE FOR 50 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)					Specimen Orientation:	Warp
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #13				Tested By:	PM
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-91-1	50 mos. @	22°C (72°F) (DRY)	1.000	0.1764	2.842	1,490	6.335	43.68	2/19/93	
BIL-GR-91-2	22°C (72°F)	"	1.000	0.1793	2.842	1,500	6.275	43.27	"	
BIL-GR-91-3	"	"	1.001	0.1795	2.842	1,454	6.069	41.84	"	
BIL-GR-91-4	"	"	1.000	0.1784	2.842	1,608	6.759	46.61	"	
BIL-GR-91-5	"	"	1.001	0.1746	2.842	1,467	6.295	43.41	"	
						Average	6.347	43.76		
						Std. Dev.	0.253	1.74		

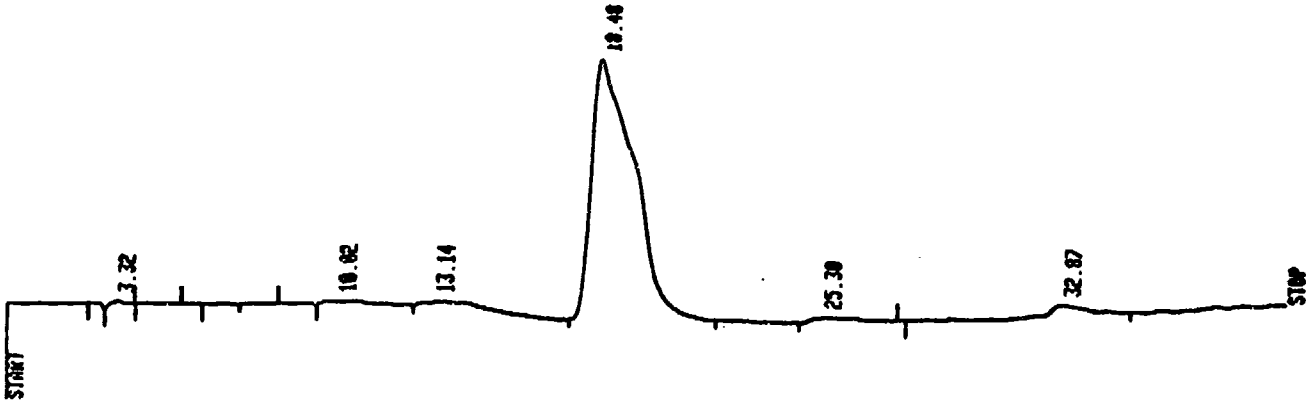


(a) Part A

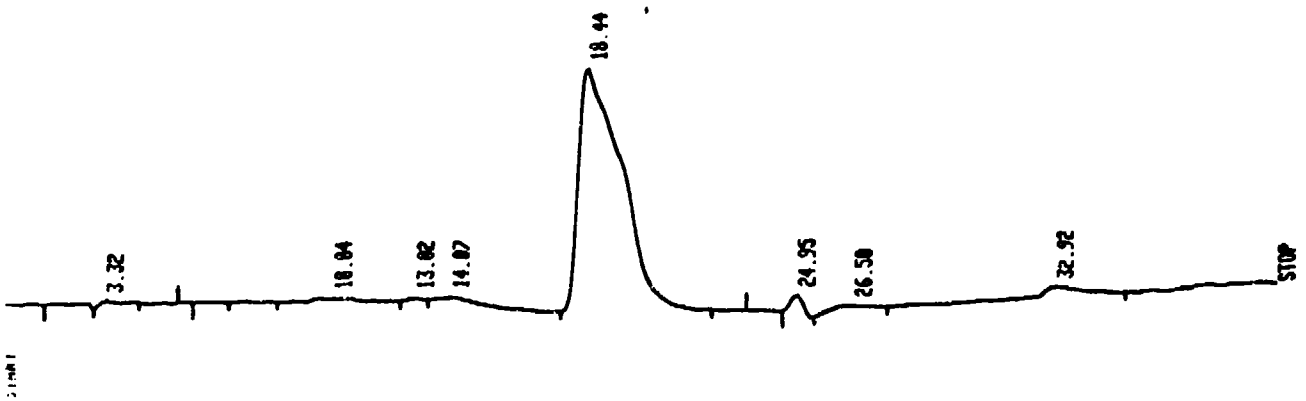


(b) Part B

Figure M.1. Initial HPLC Spectra for EA9396 Parts A and B.

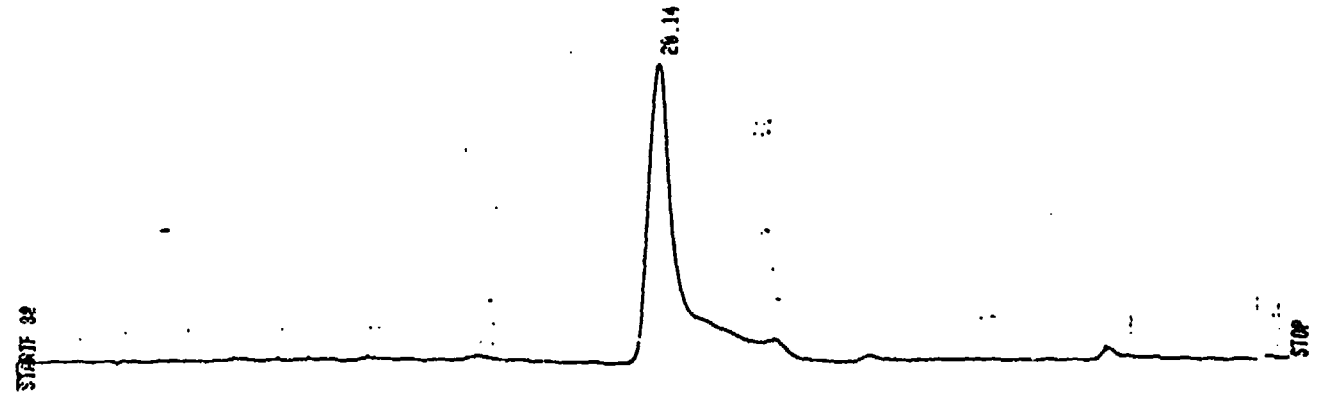


(a) Stored 1 month at 38°C (100°F).

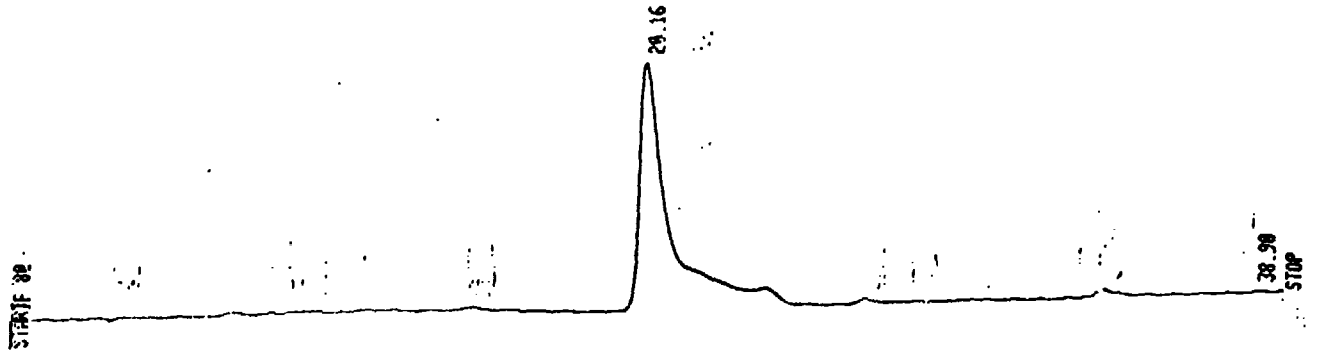


(b) Stored 1 month at 49°C (120°F).

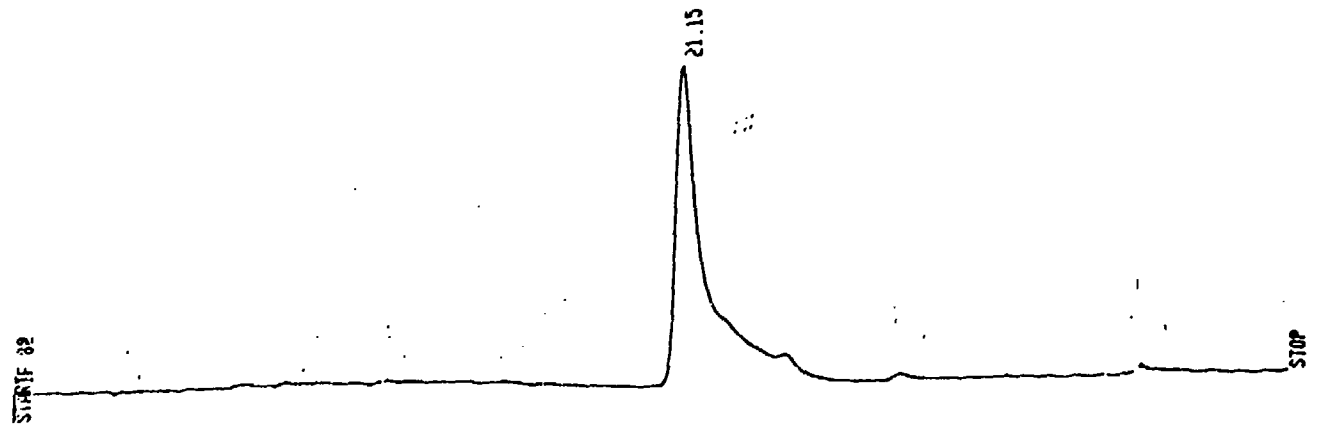
Figure M.2. HPLC Spectra for EA9396, Part A After One Month Storage.



(a) Stored 6 months at 22°C (72°F).

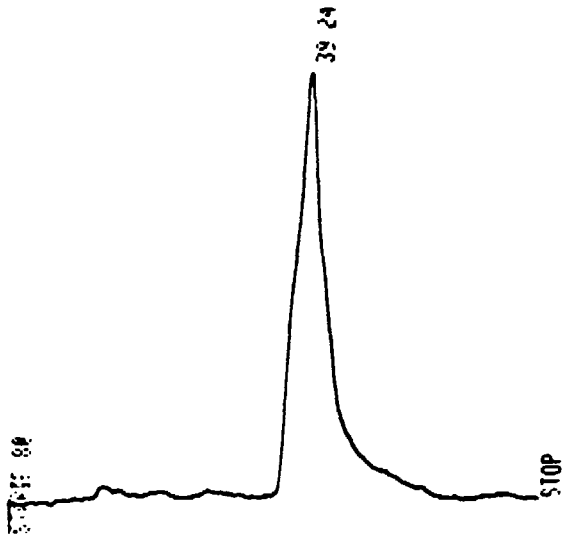


(b) Stored 6 months at 38°C (100°F).

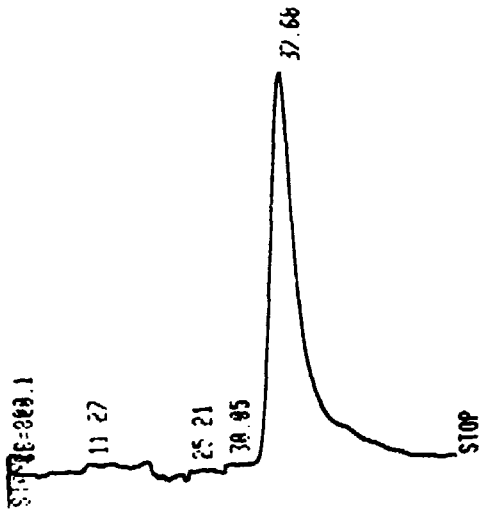


(c) Stored 6 months at 49°C (120°F).

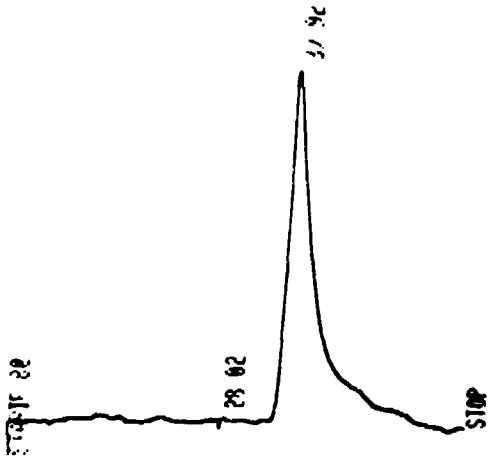
Figure M.3. HPLC Spectra for EA9396, Part A After Six Months Storage.



(a) Stored 12 Months at 22°C (72°F).

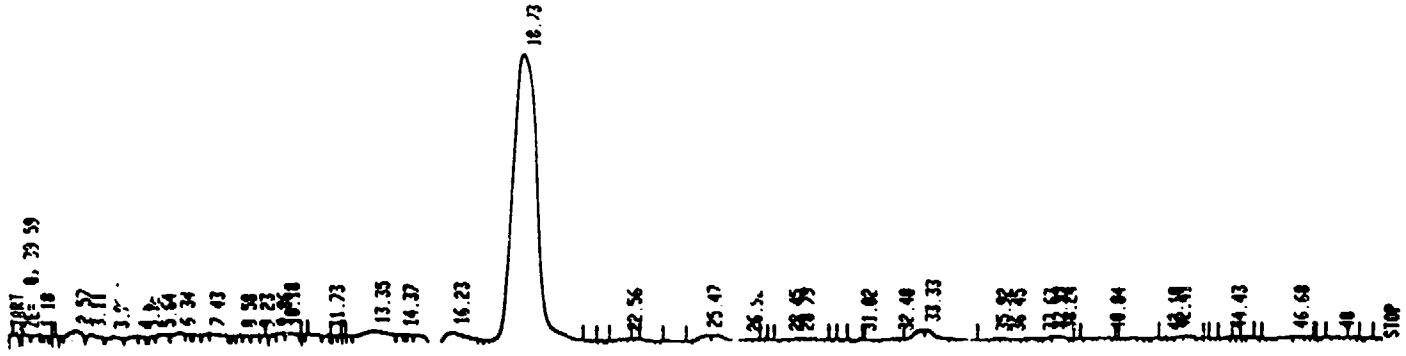


(b) Stored 12 Months at 38°C (100°F).

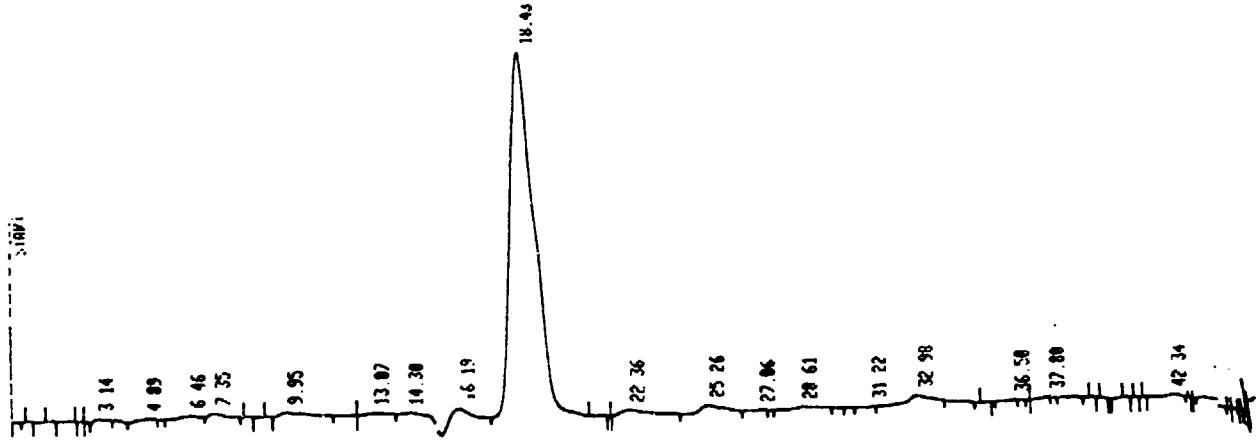


(c) Stored 12 Months at 49°C (120°F).

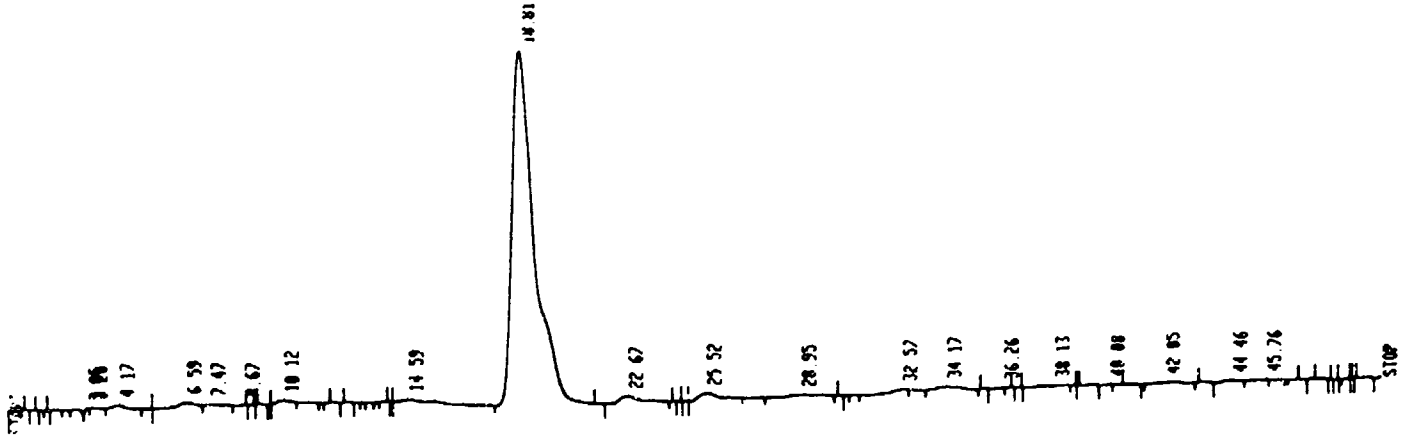
Figure M.4. HPLC Spectra for EA9396, Part A After 12 Months Storage.



(a) Stored 18 months at 22°C (72°F).

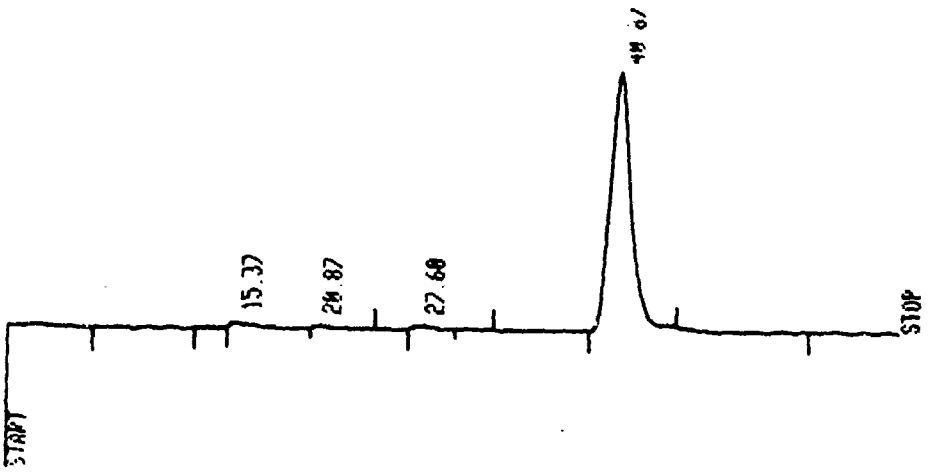


(b) Stored 18 months at 38°C (100°F).

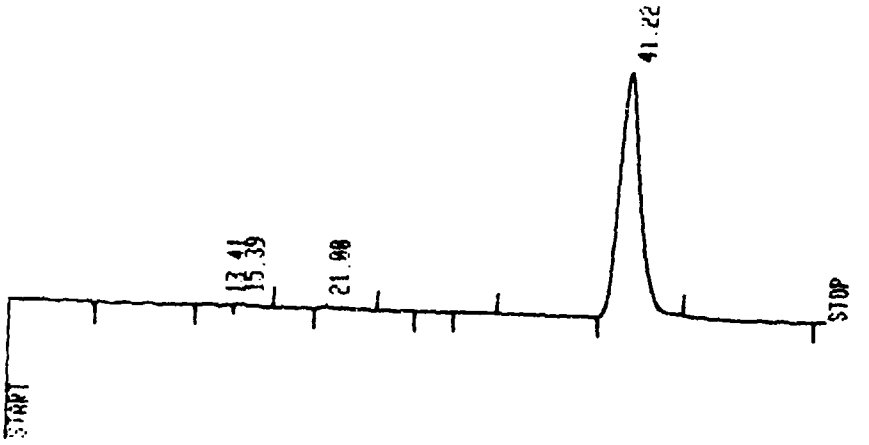


(c) Stored 18 months at 49°C (120°F).

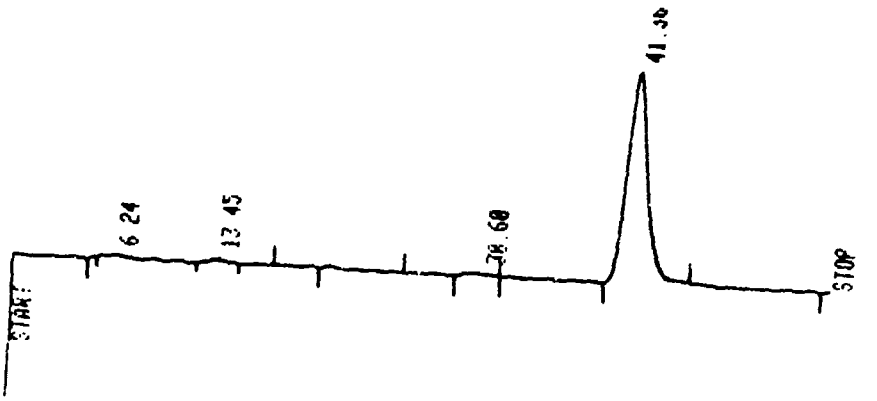
Figure M.5. HPLC Spectra of EA9396, Part A After 18 Months Storage.



(a) Stored 24 months at 22°C (72°F).



(b) Stored 24 months at 38°C (100°F).



(c) Stored 24 months at 49°C (120°F).

Figure M.6. HPLC Spectra of EA9396, Part A After 24 Months Storage.

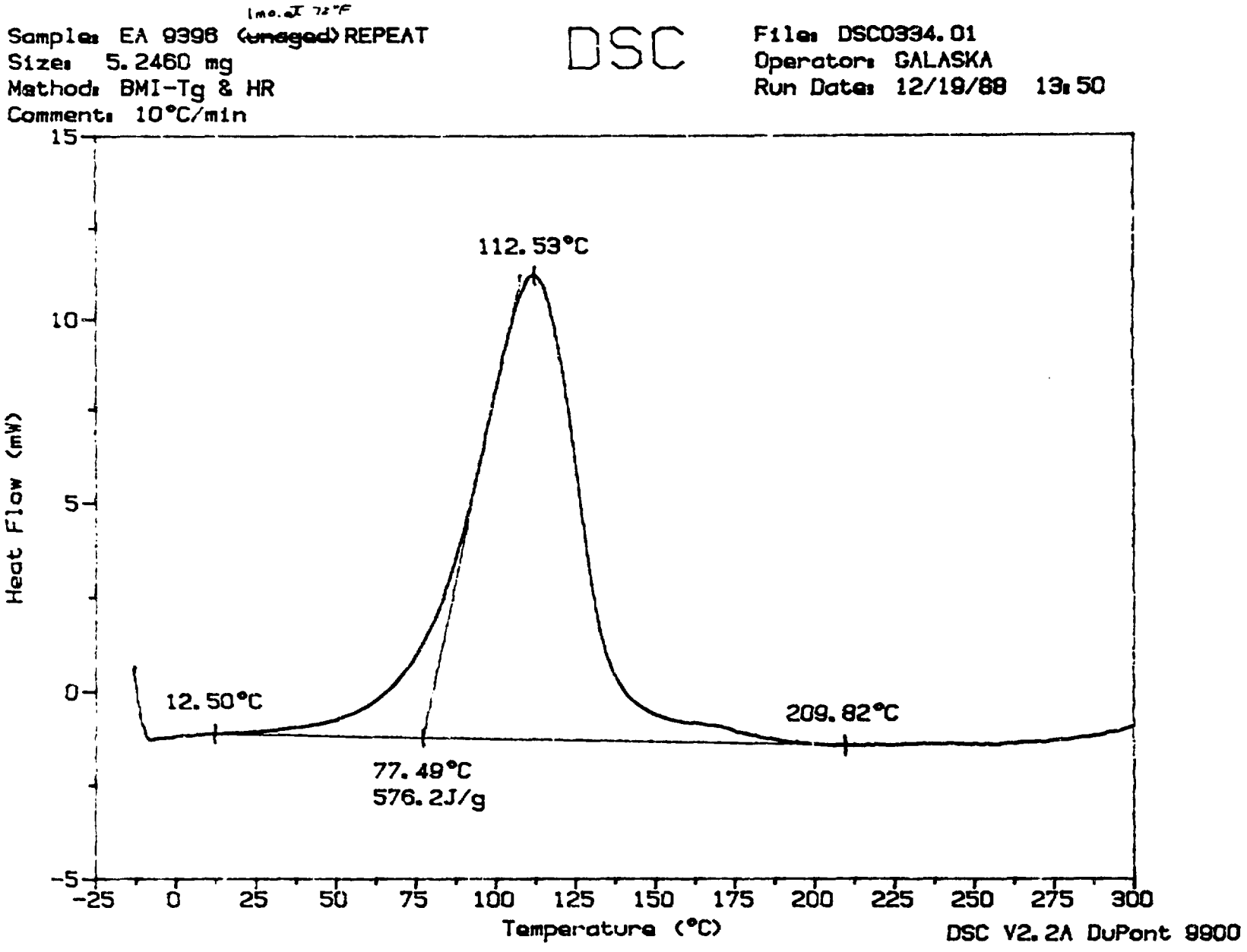


Figure M.7. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 1 Month.

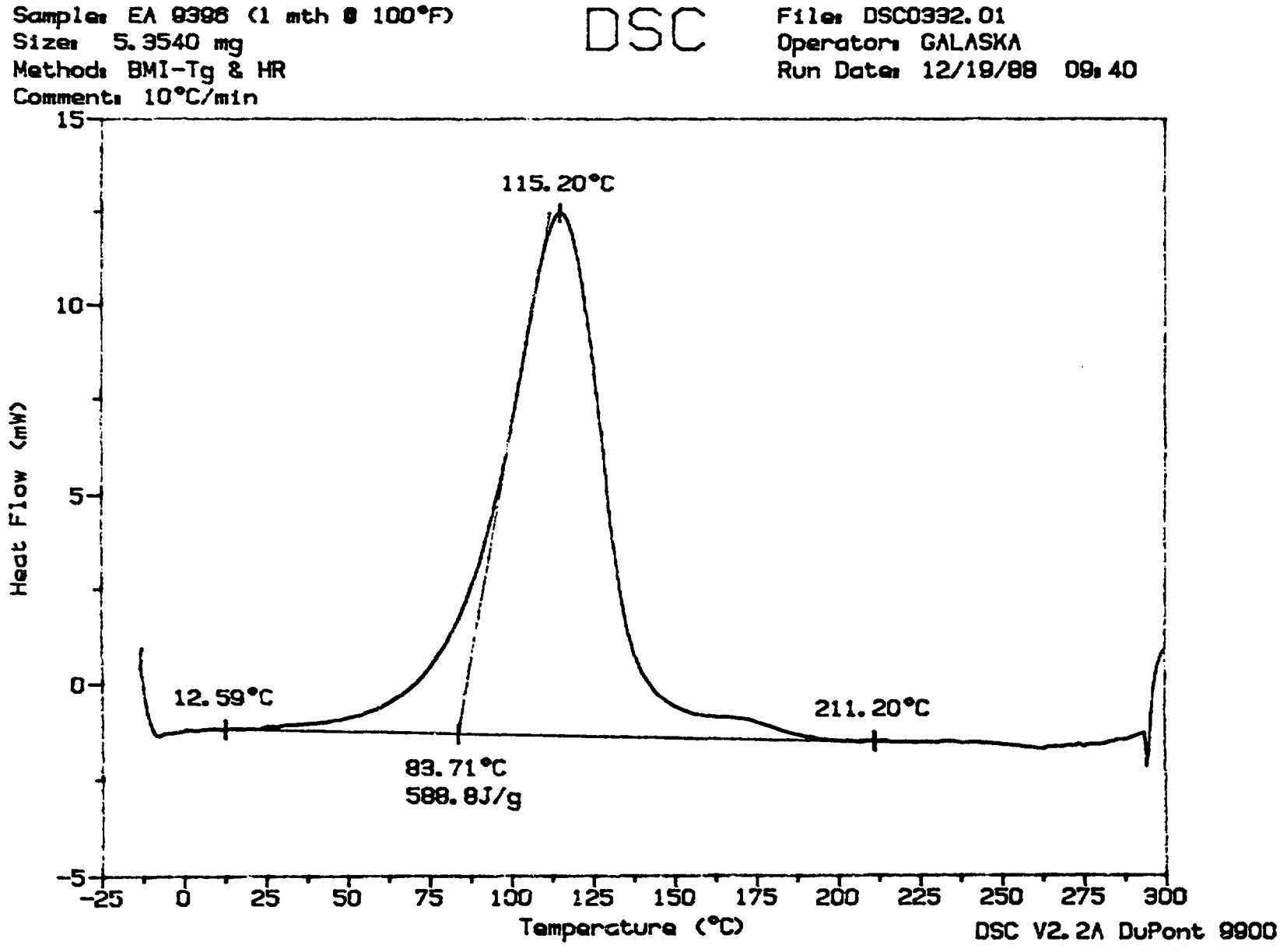


Figure M.8. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 1 Month.

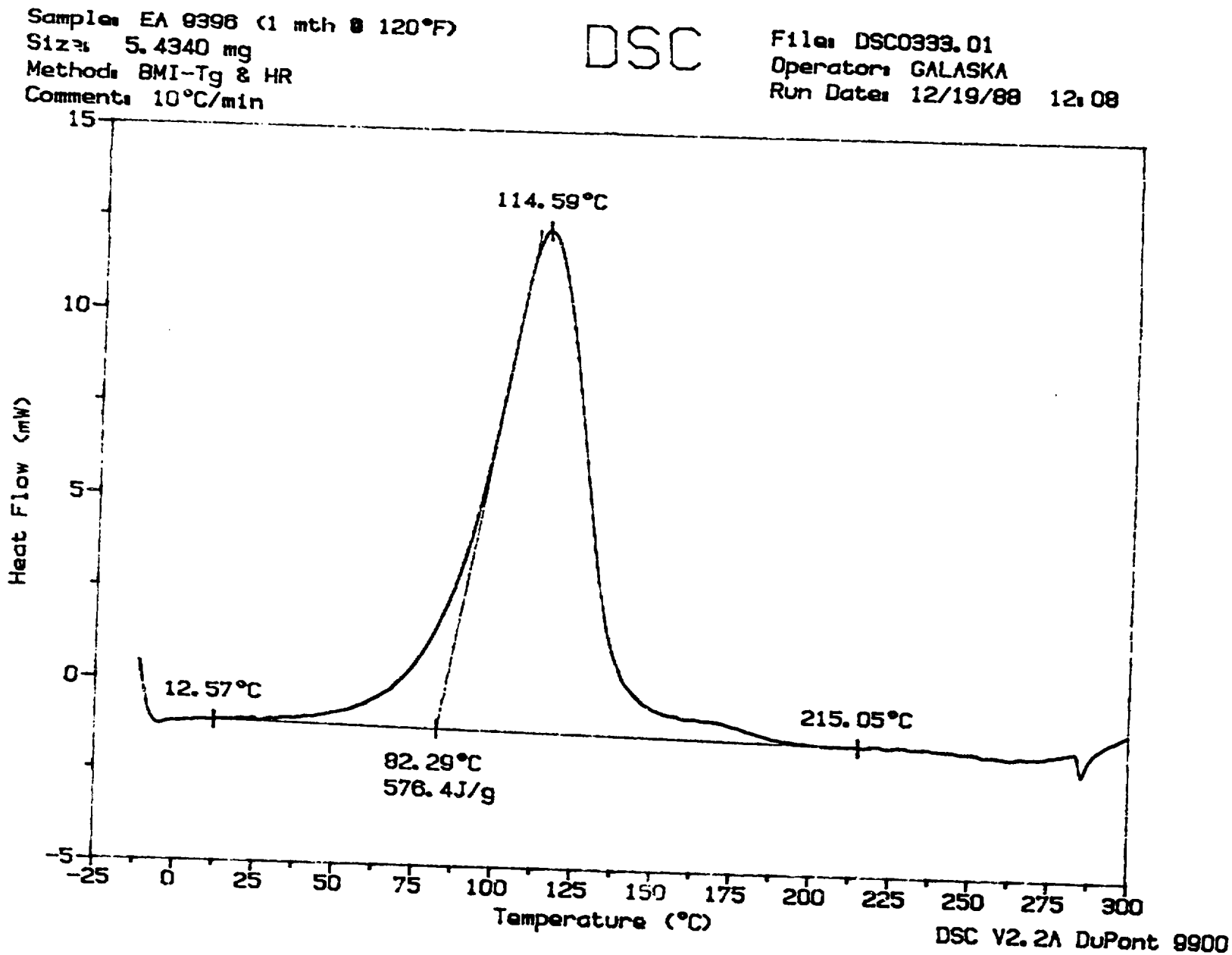


Figure M.9. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 1 Month.

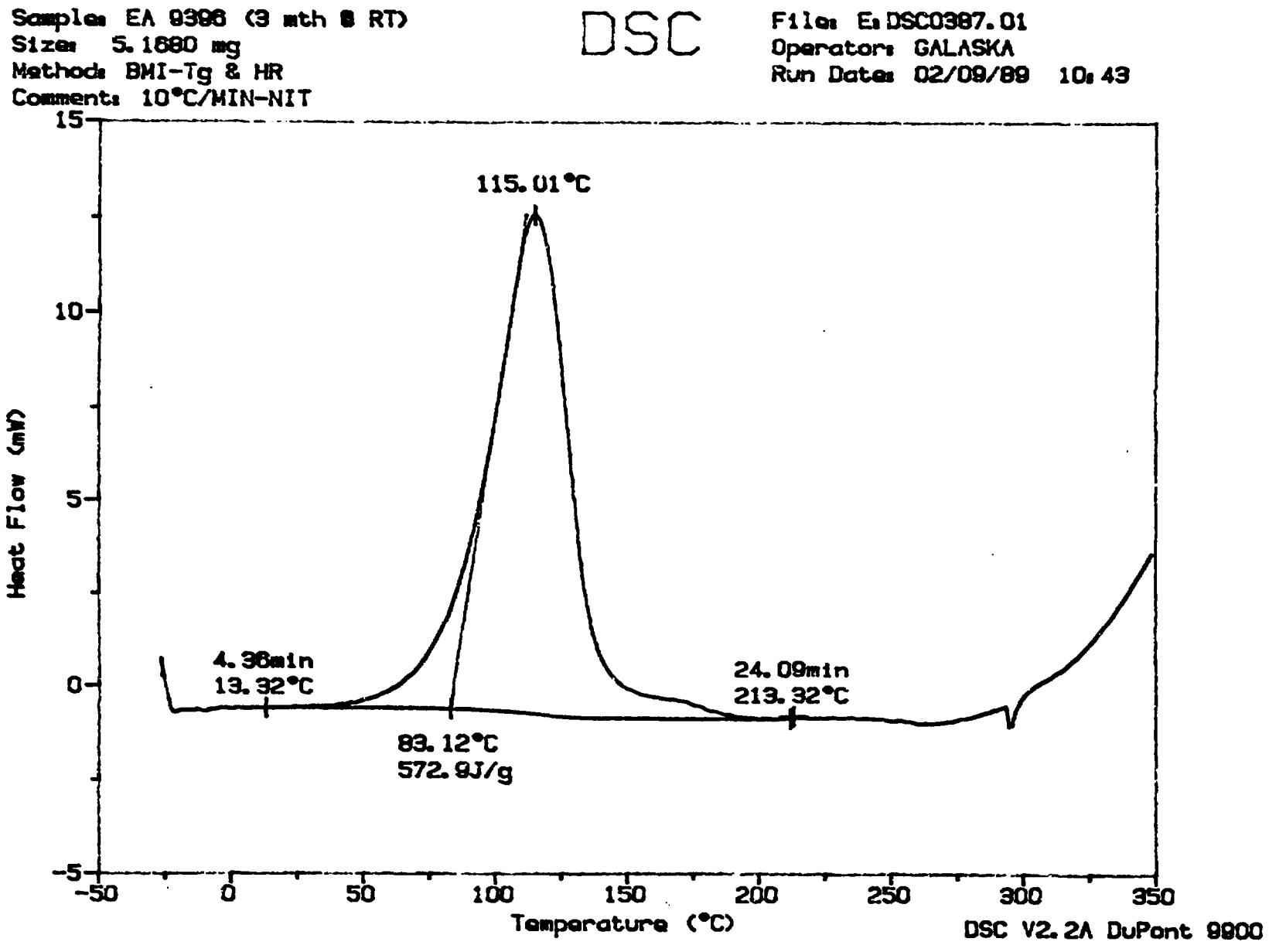


Figure M.10. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 3 Months.

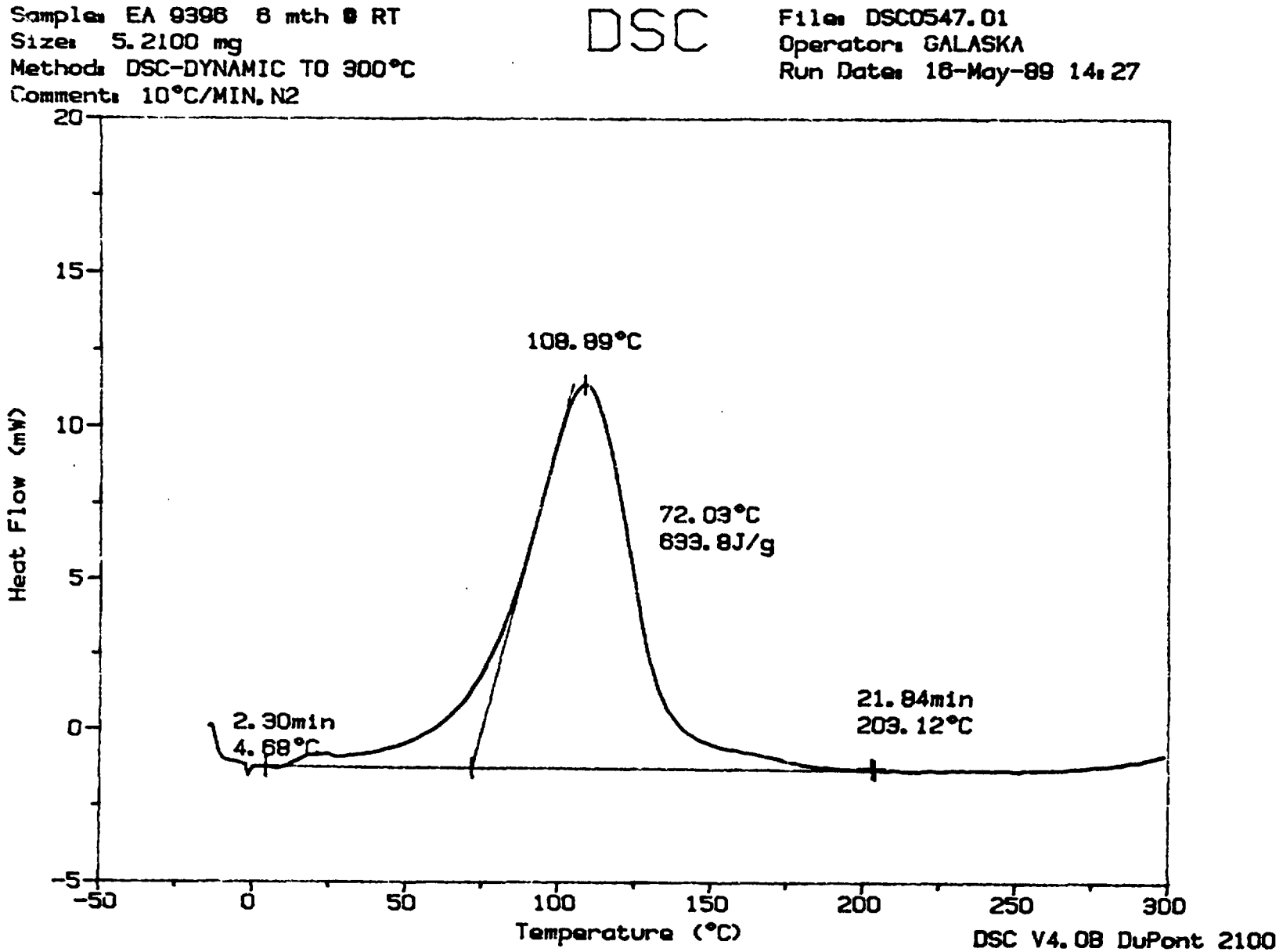


Figure M.11. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 6 Months.

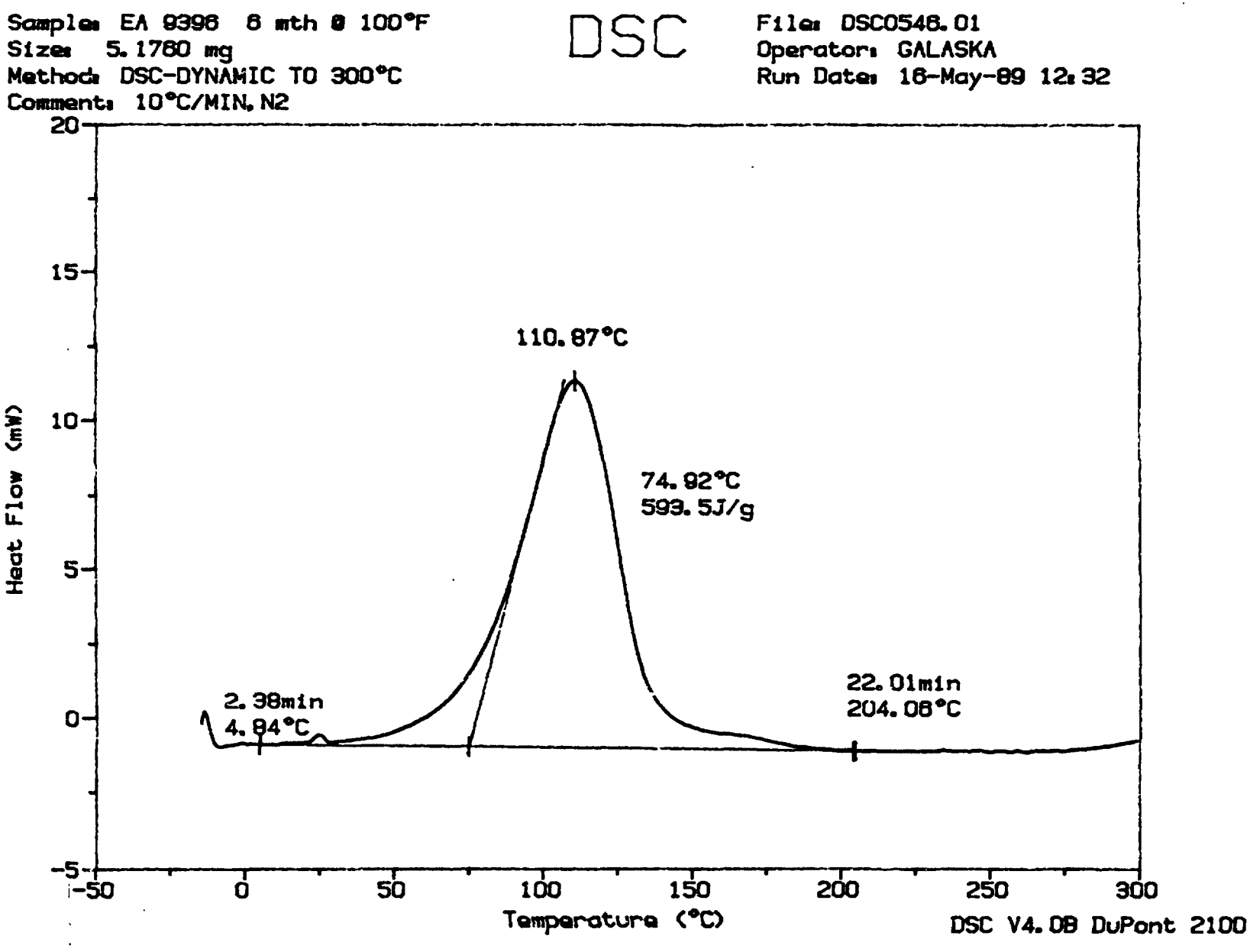


Figure M.12. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 6 Months.

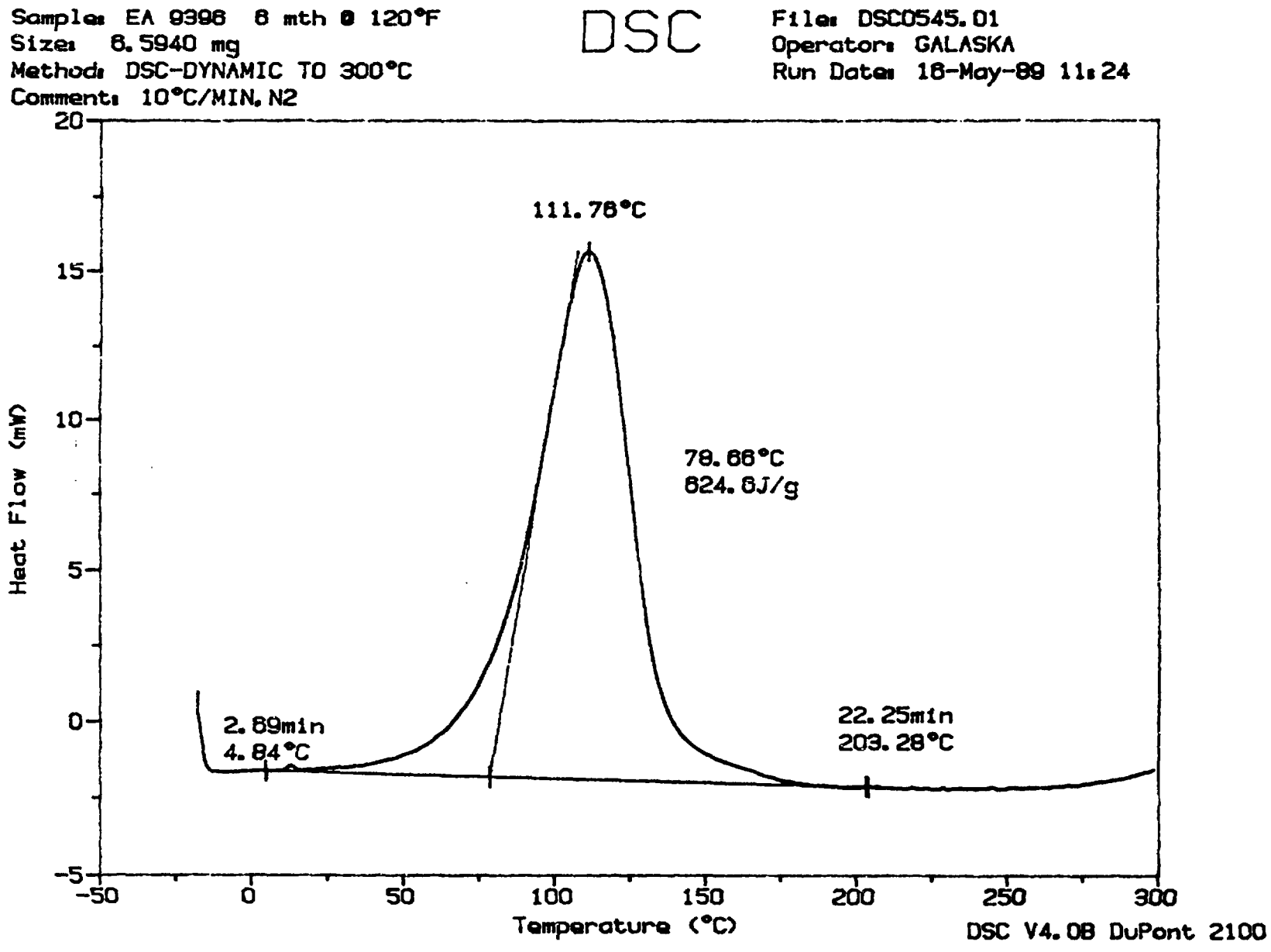


Figure M.13. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 6 Months.

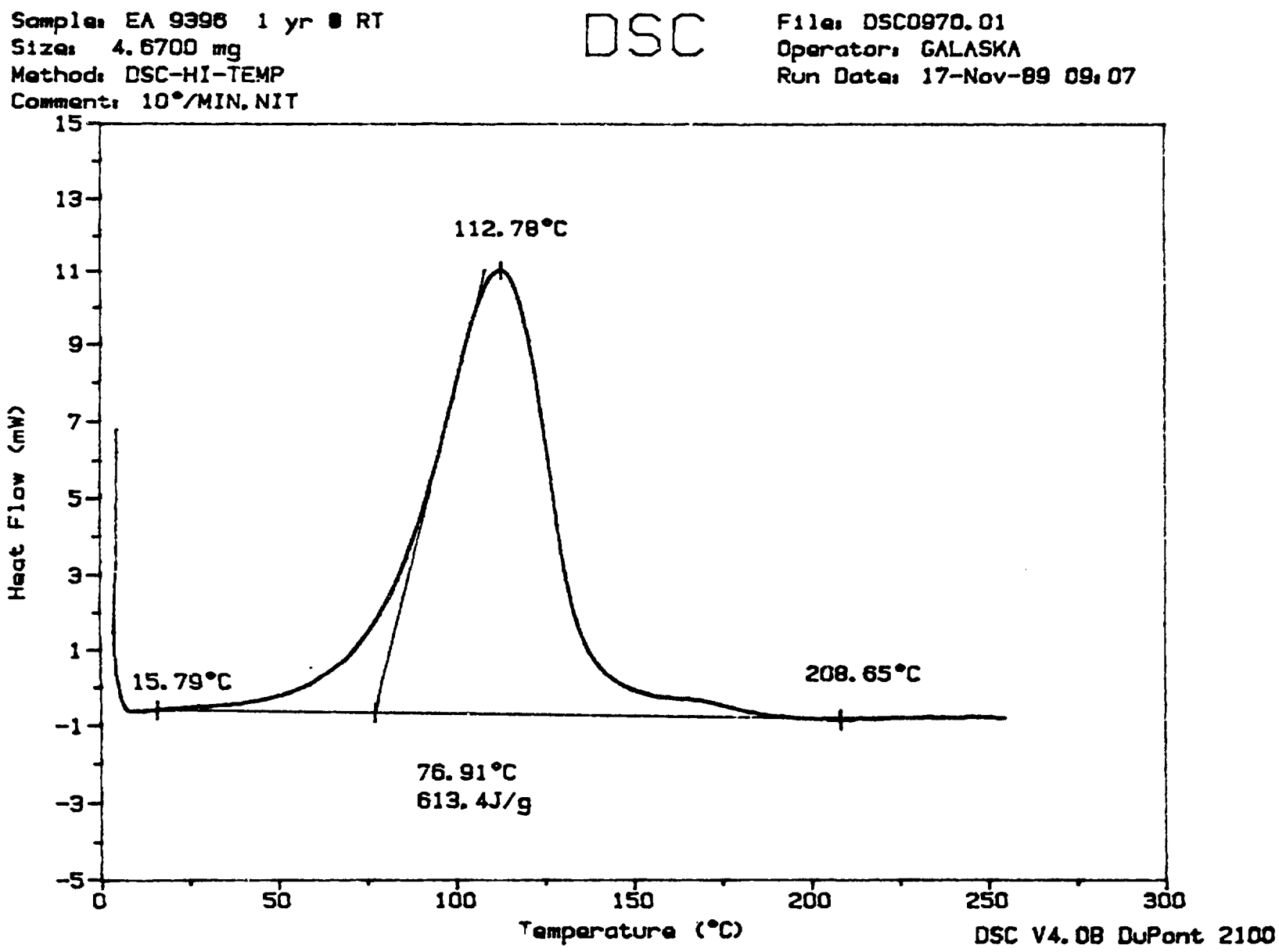


Figure M.14. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 12 Months.

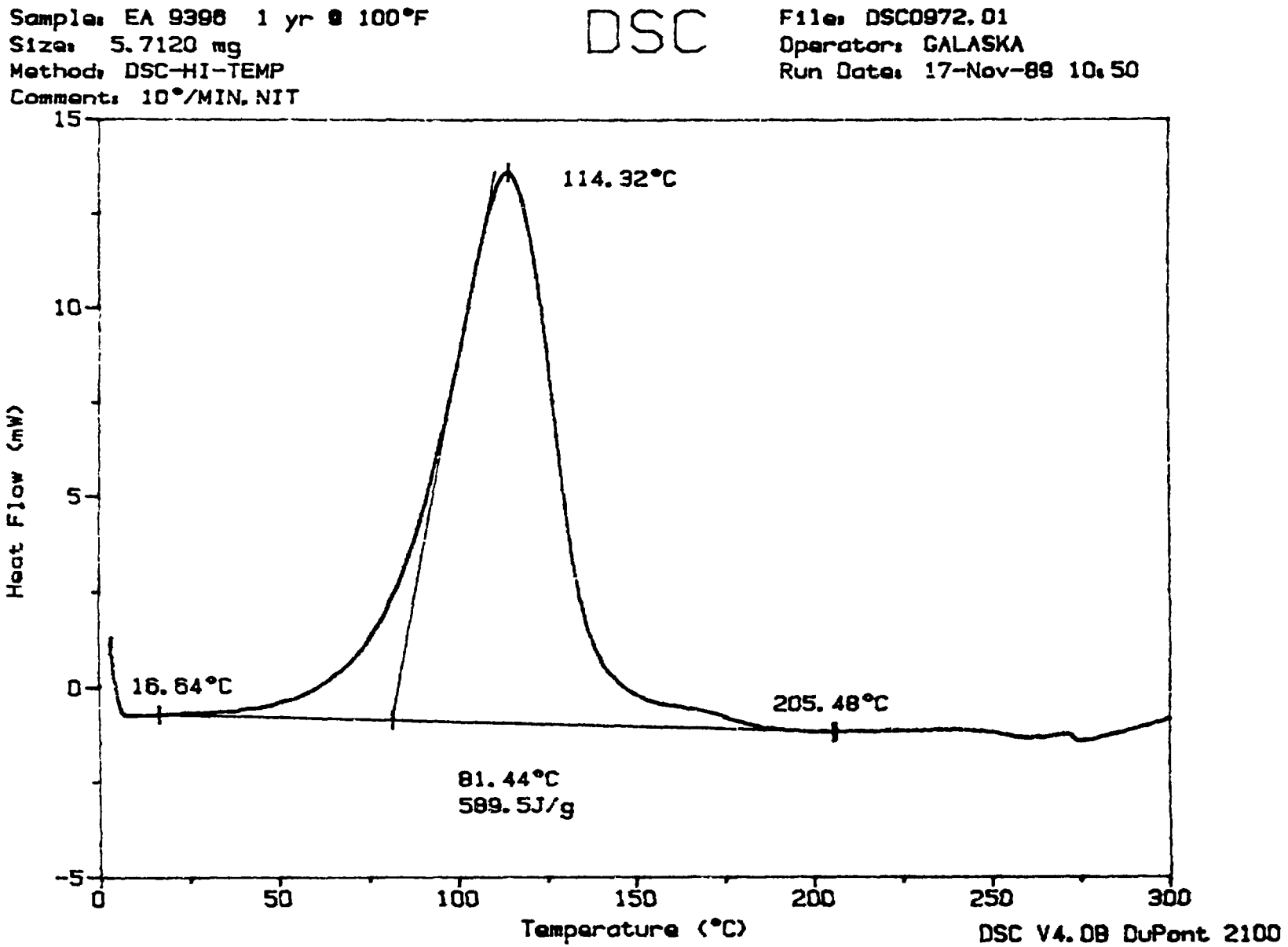


Figure M.15. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 12 Months.

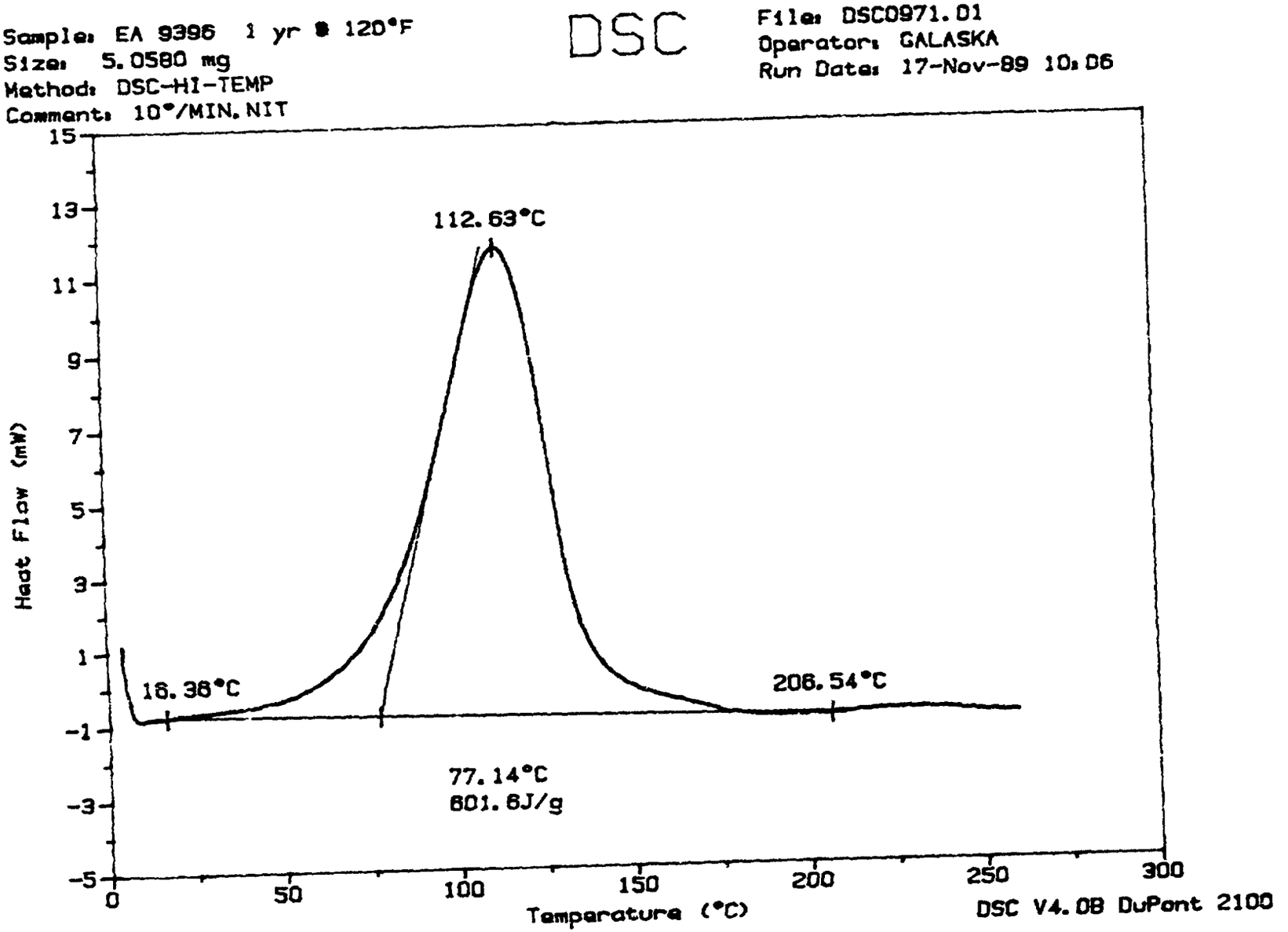


Figure M.16. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 12 Months.

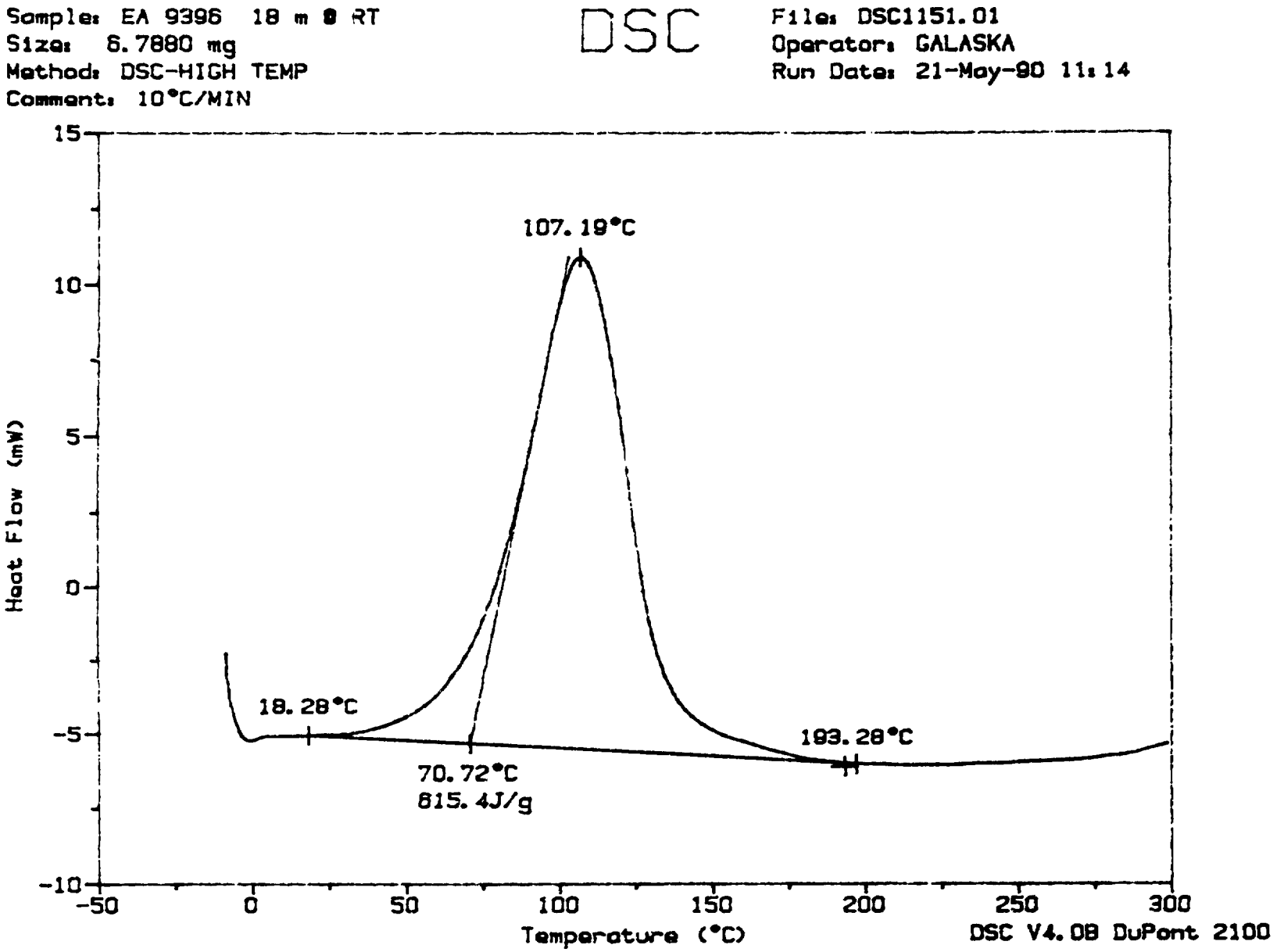


Figure M.17. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 18 Months.

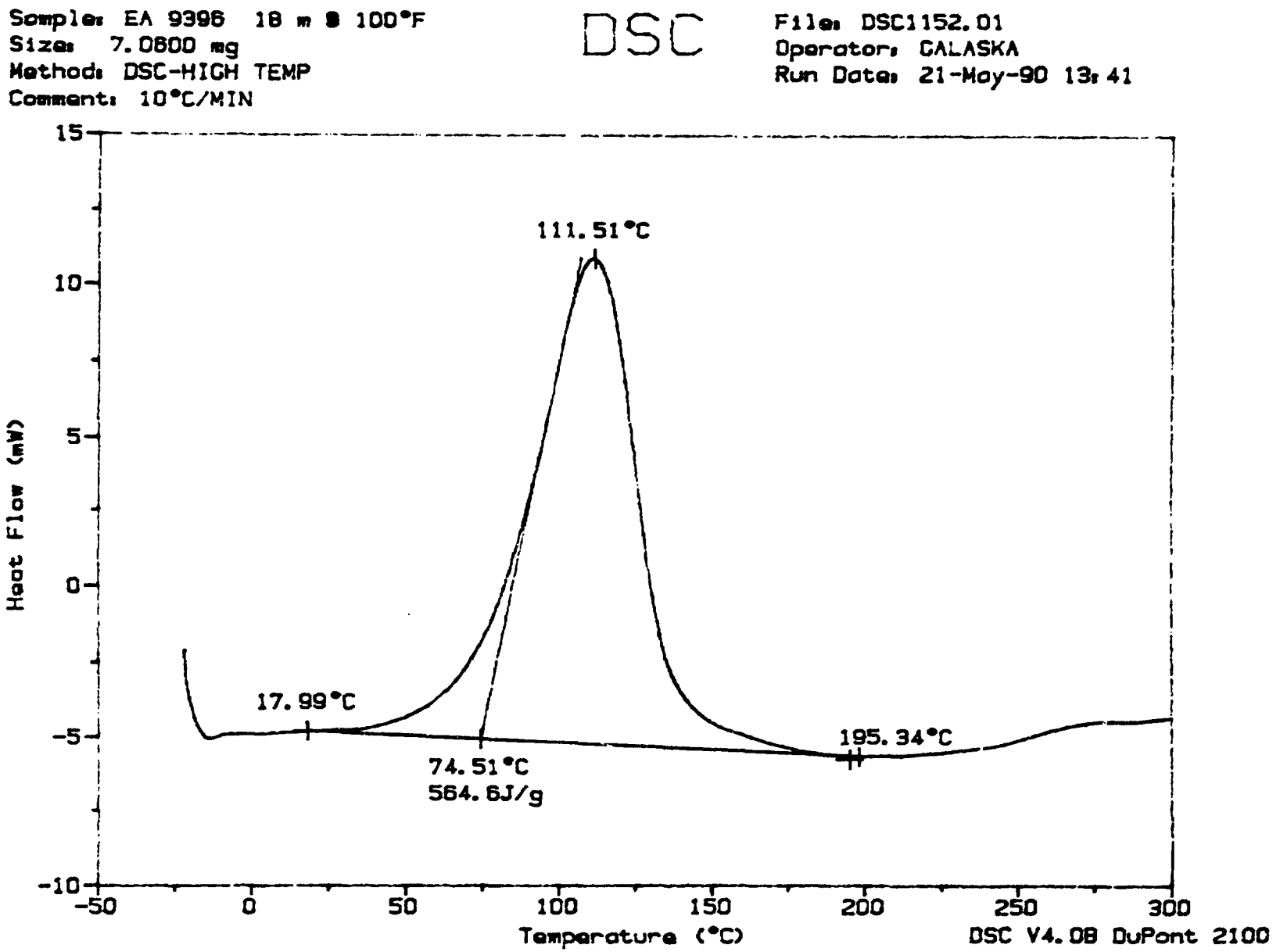


Figure M.18. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 18 Months.

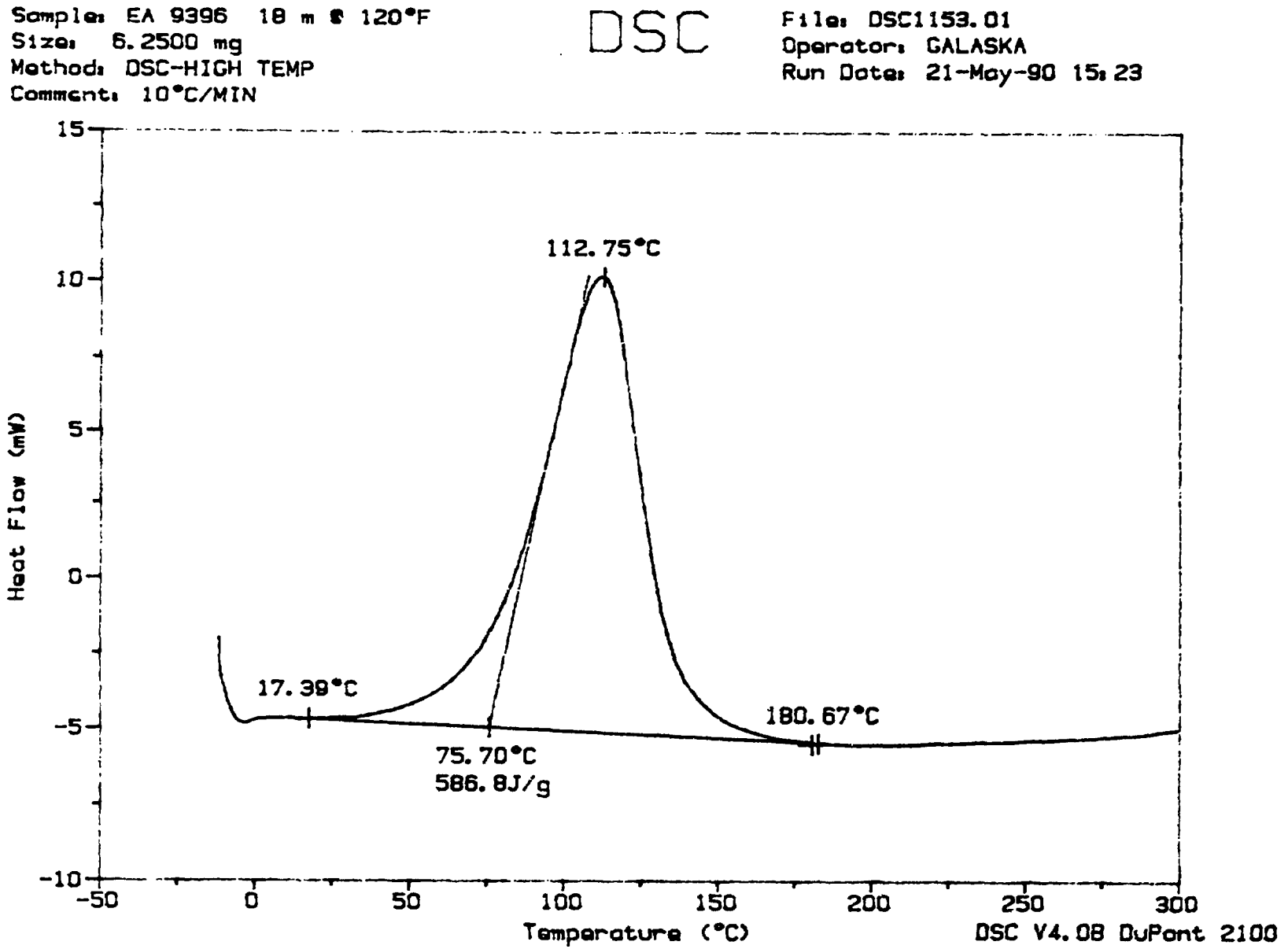


Figure M.19. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 18 Months.

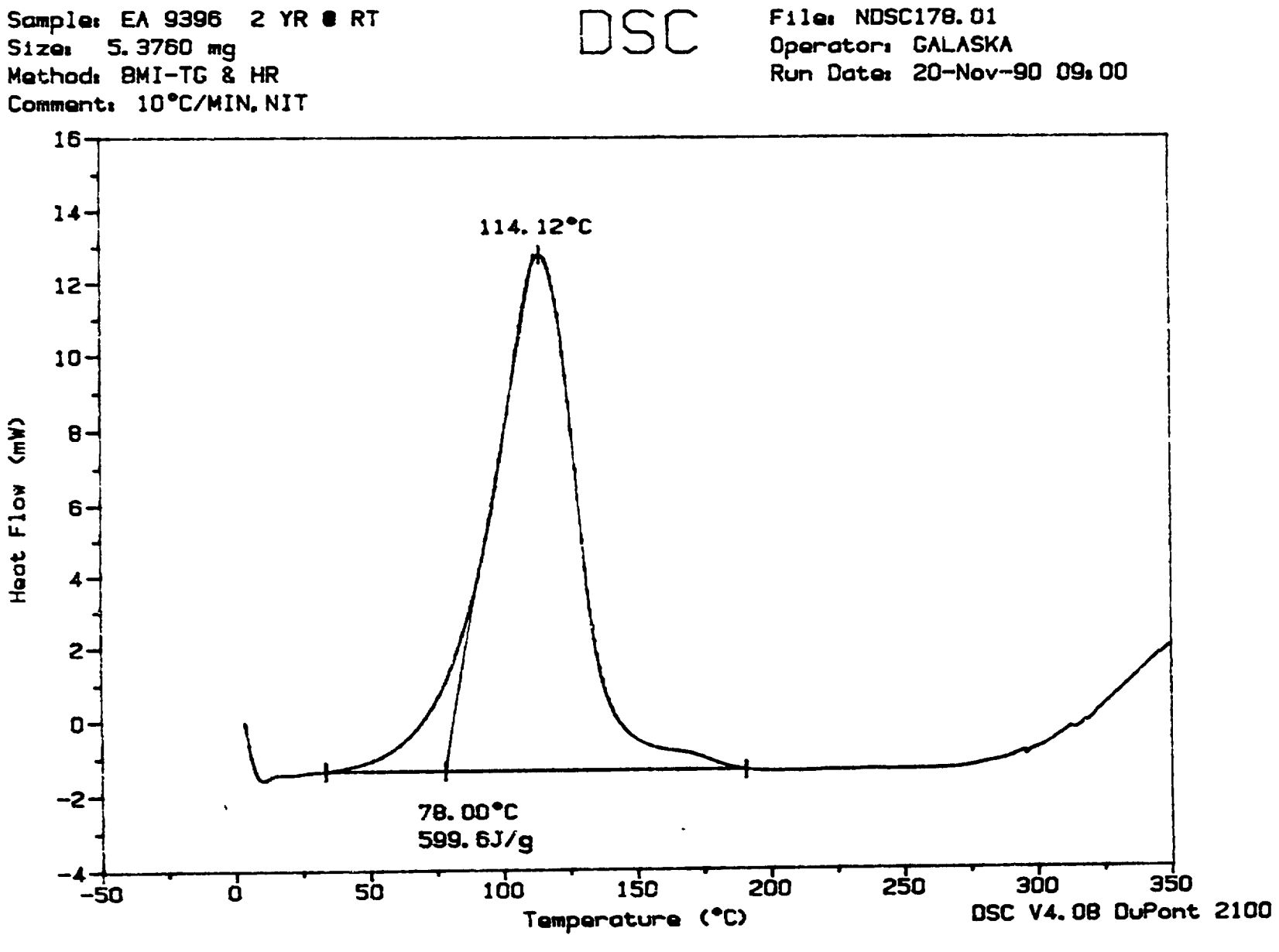


Figure M.20. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 24 Months.

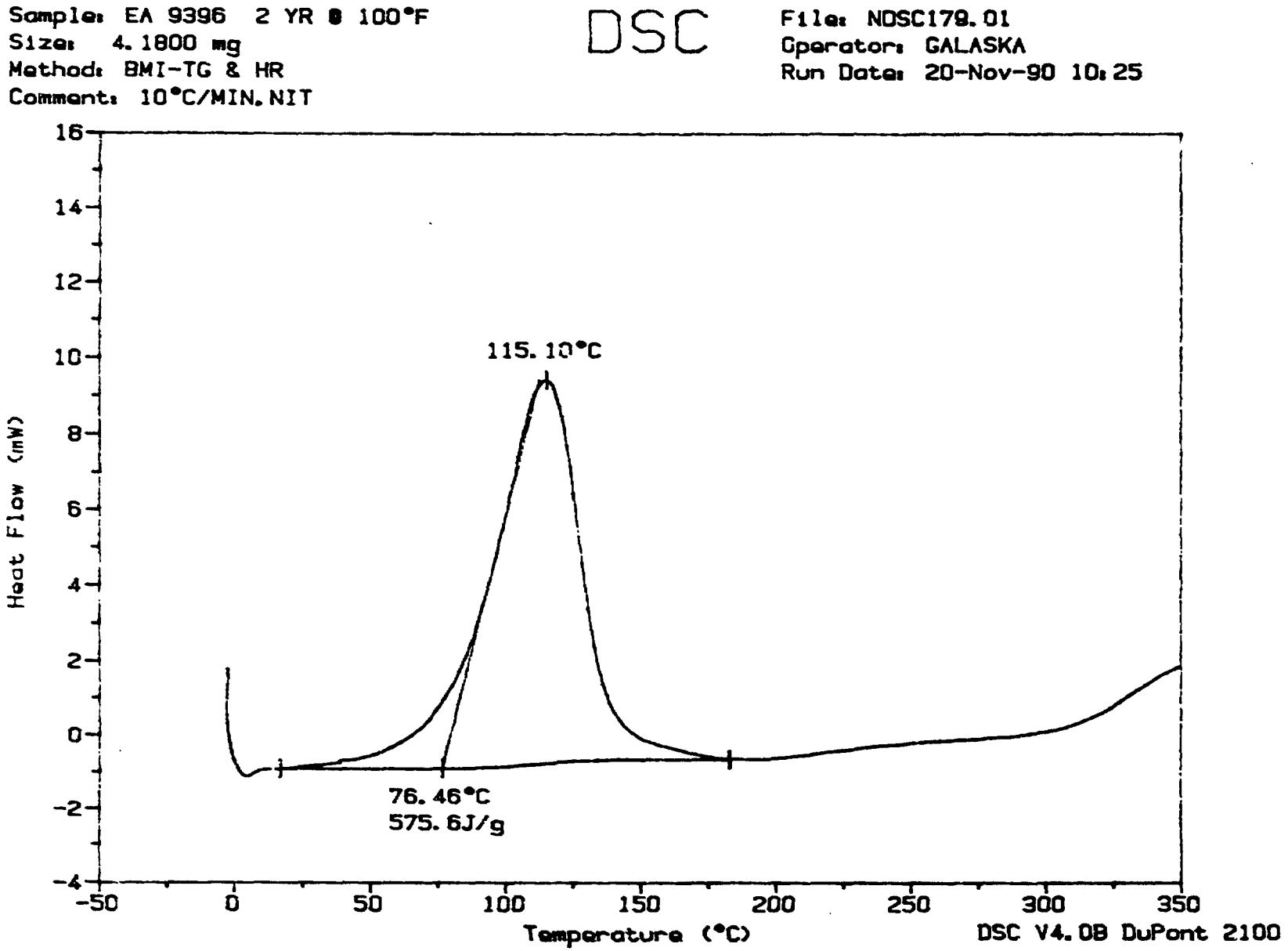


Figure M.21. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 24 Months.

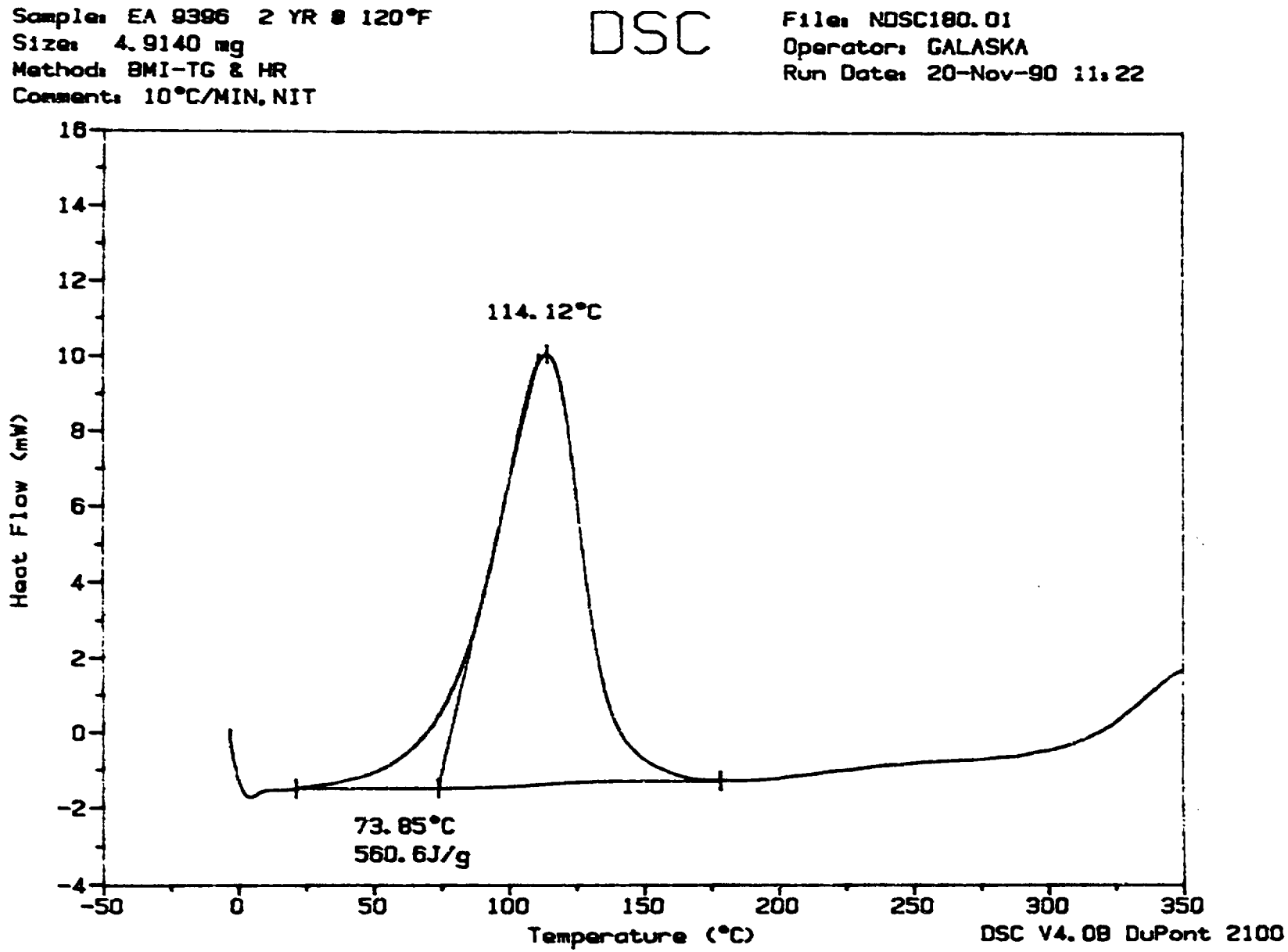


Figure M.22. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 24 Months.

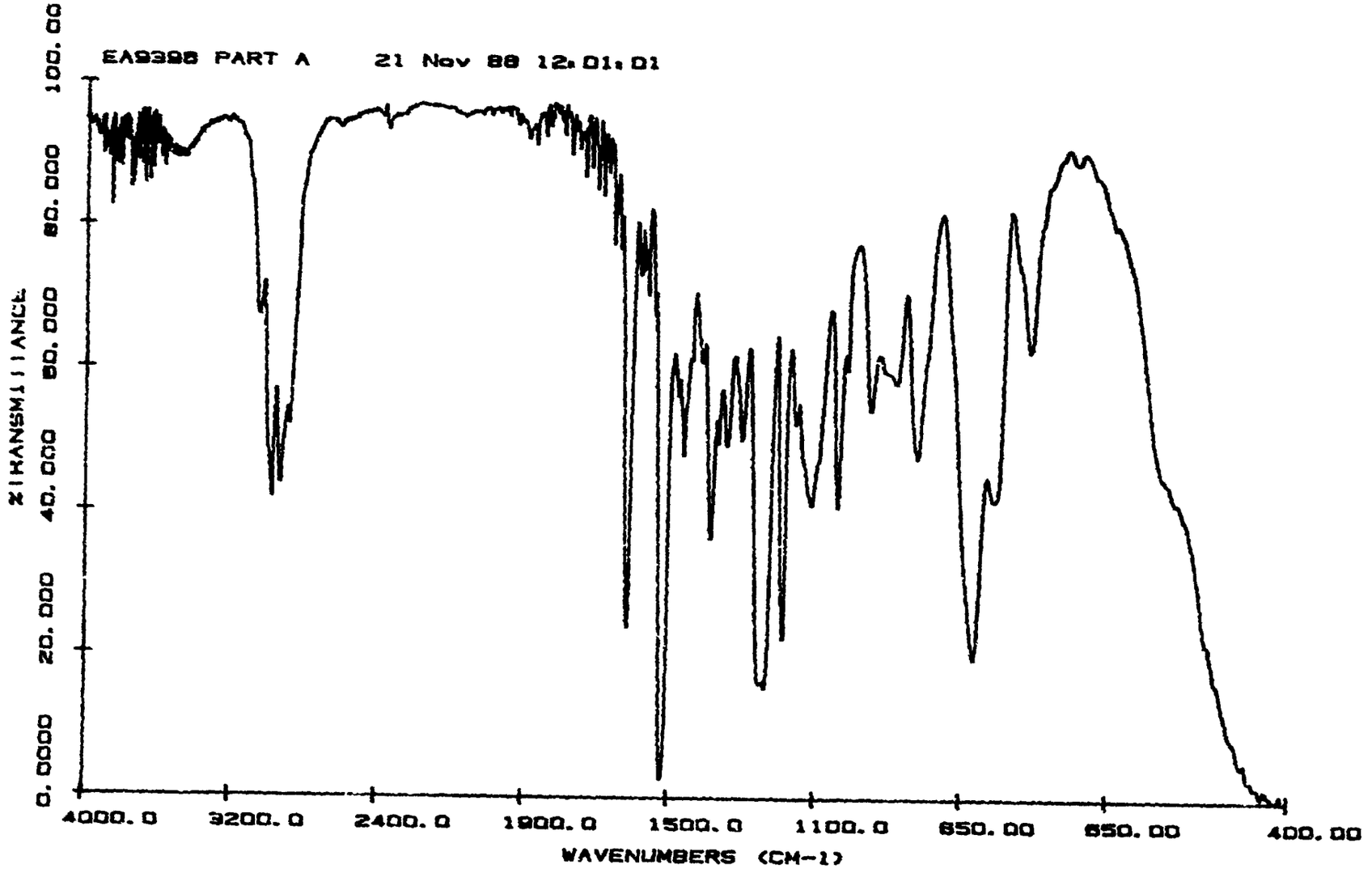


Figure M.23. FTIR Spectra for EA9396, Part A, Initial.

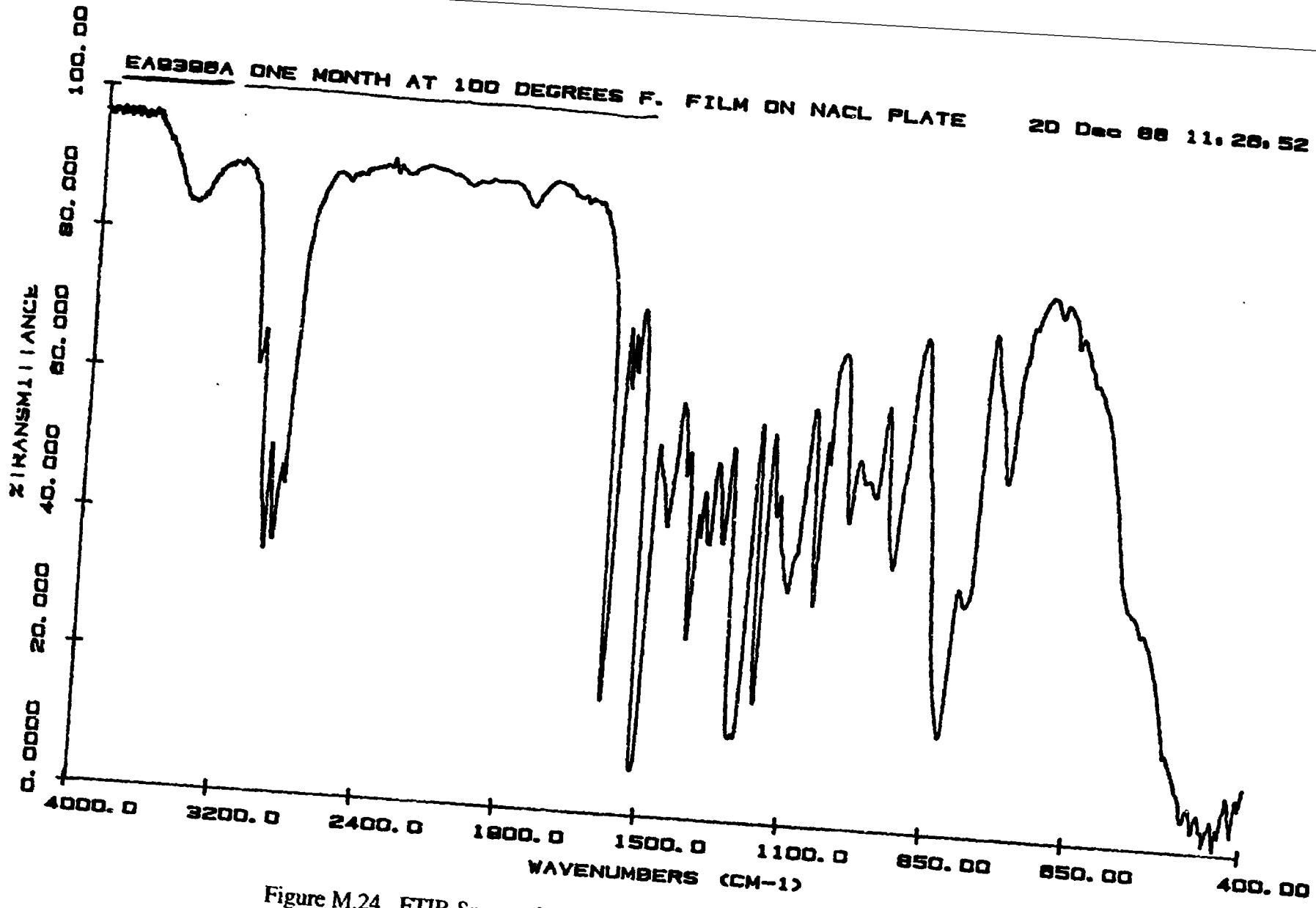


Figure M.24. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 1 Month.

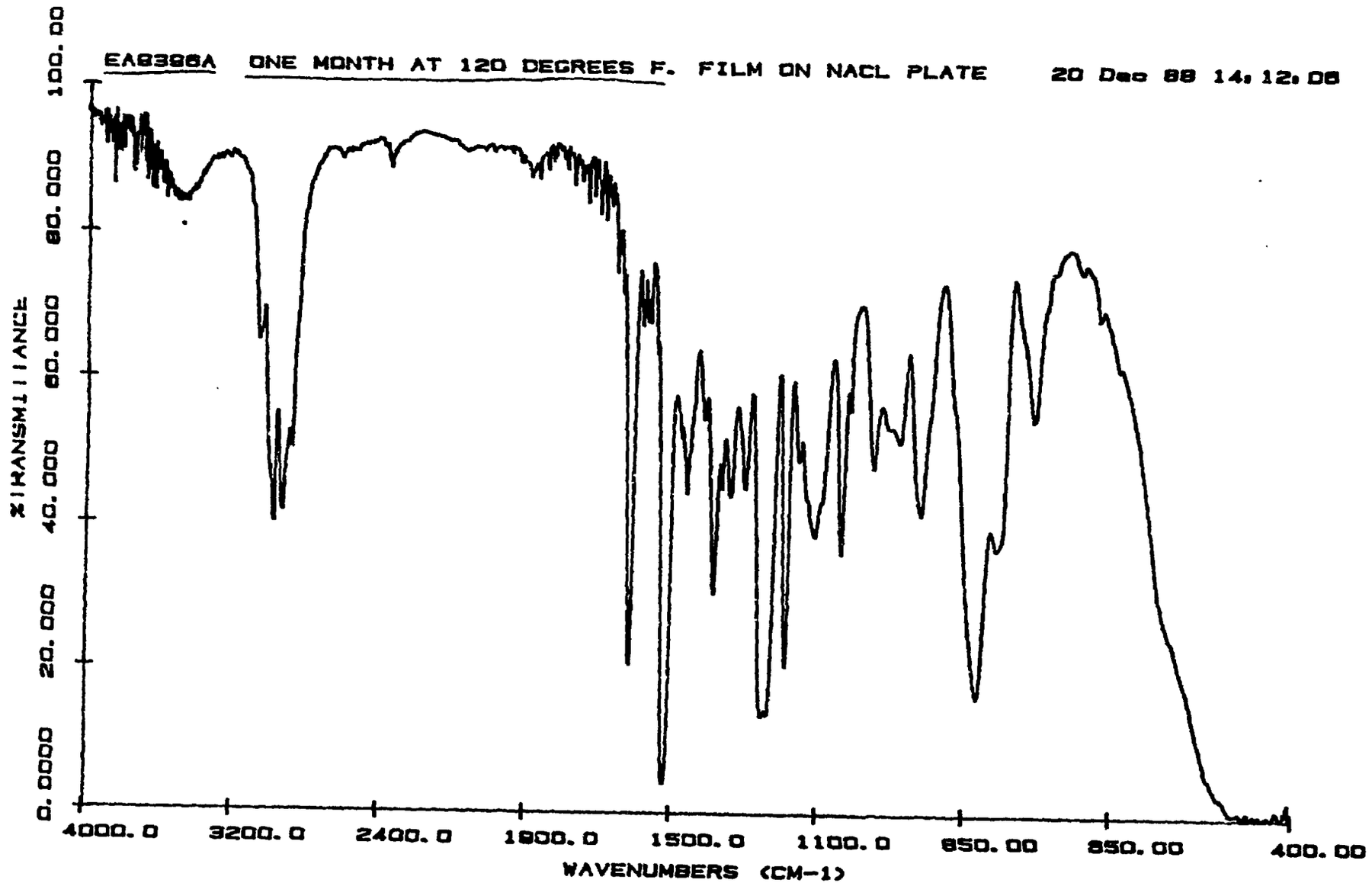


Figure M.25. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 1 Month.

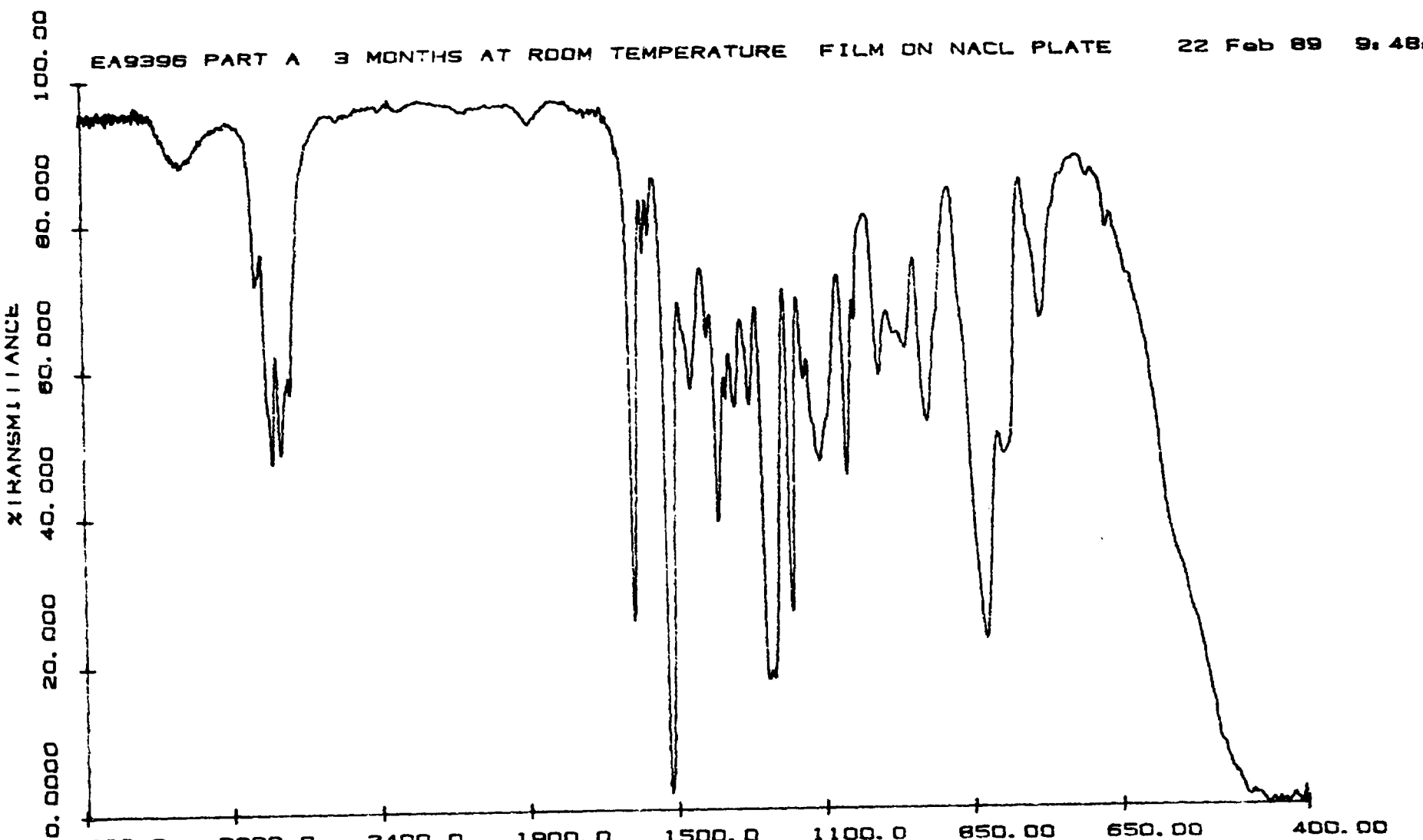


Figure M.26. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 3 Months.

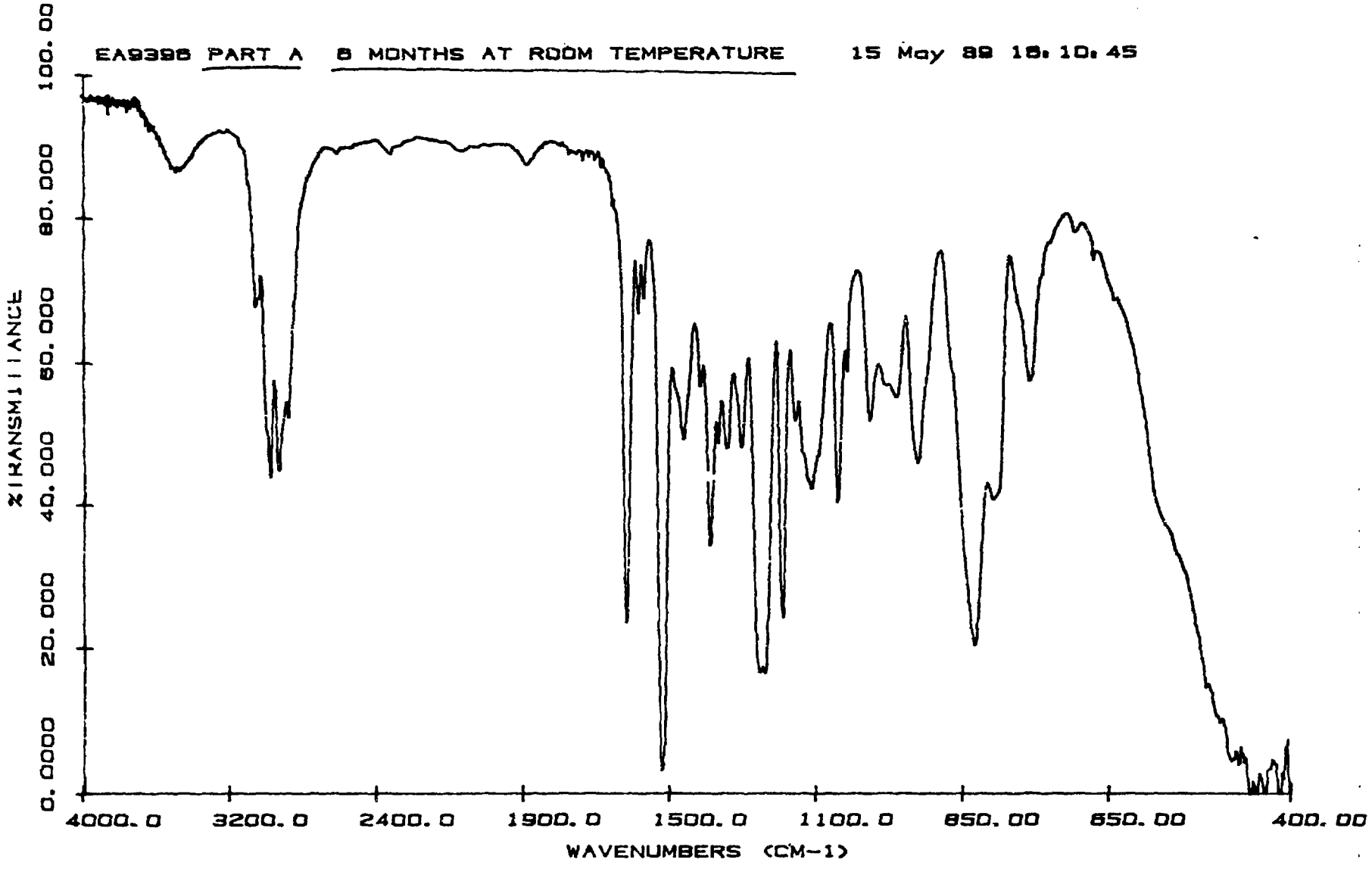


Figure M.27. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 6 Months.

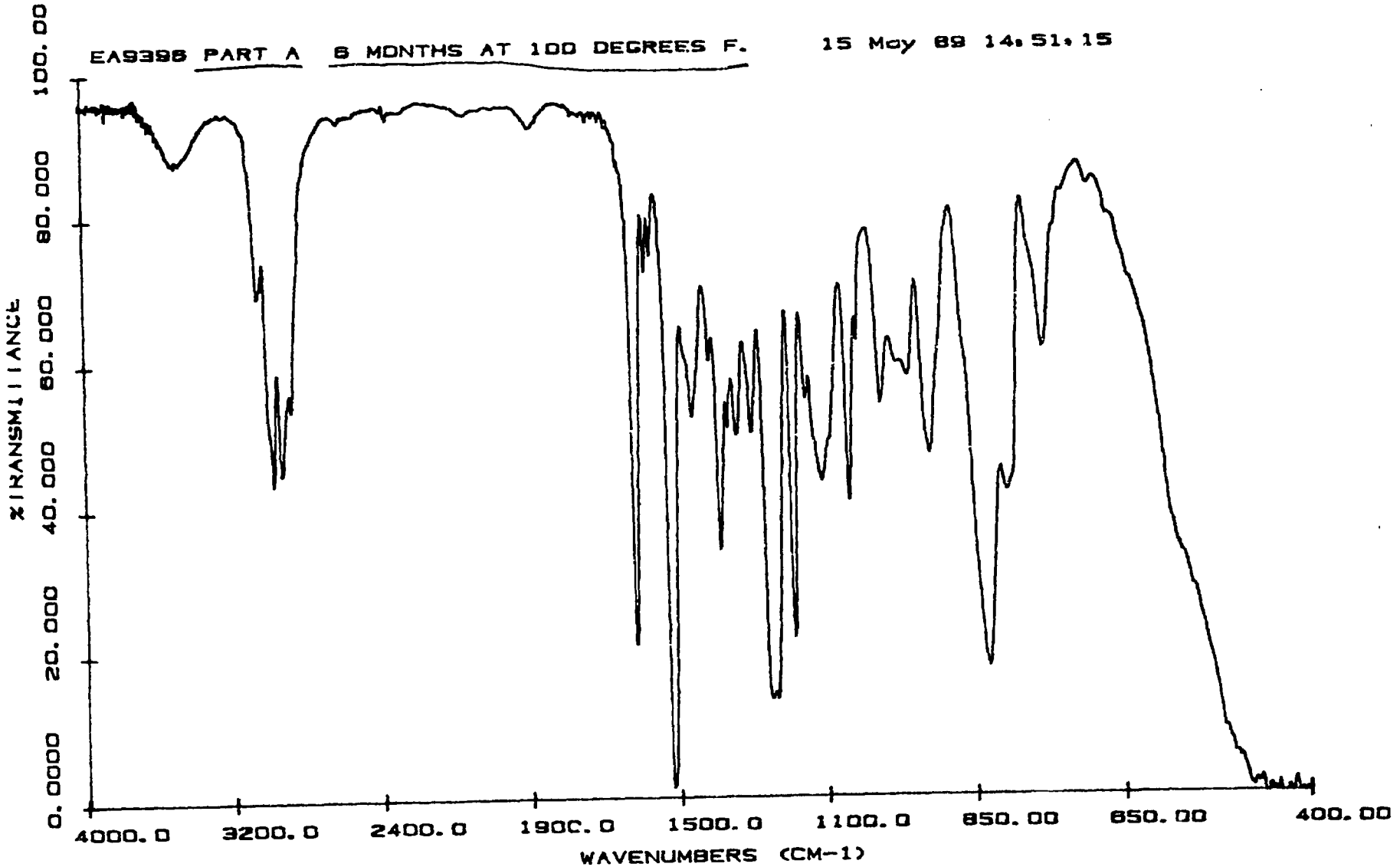


Figure M.28. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 6 Months.

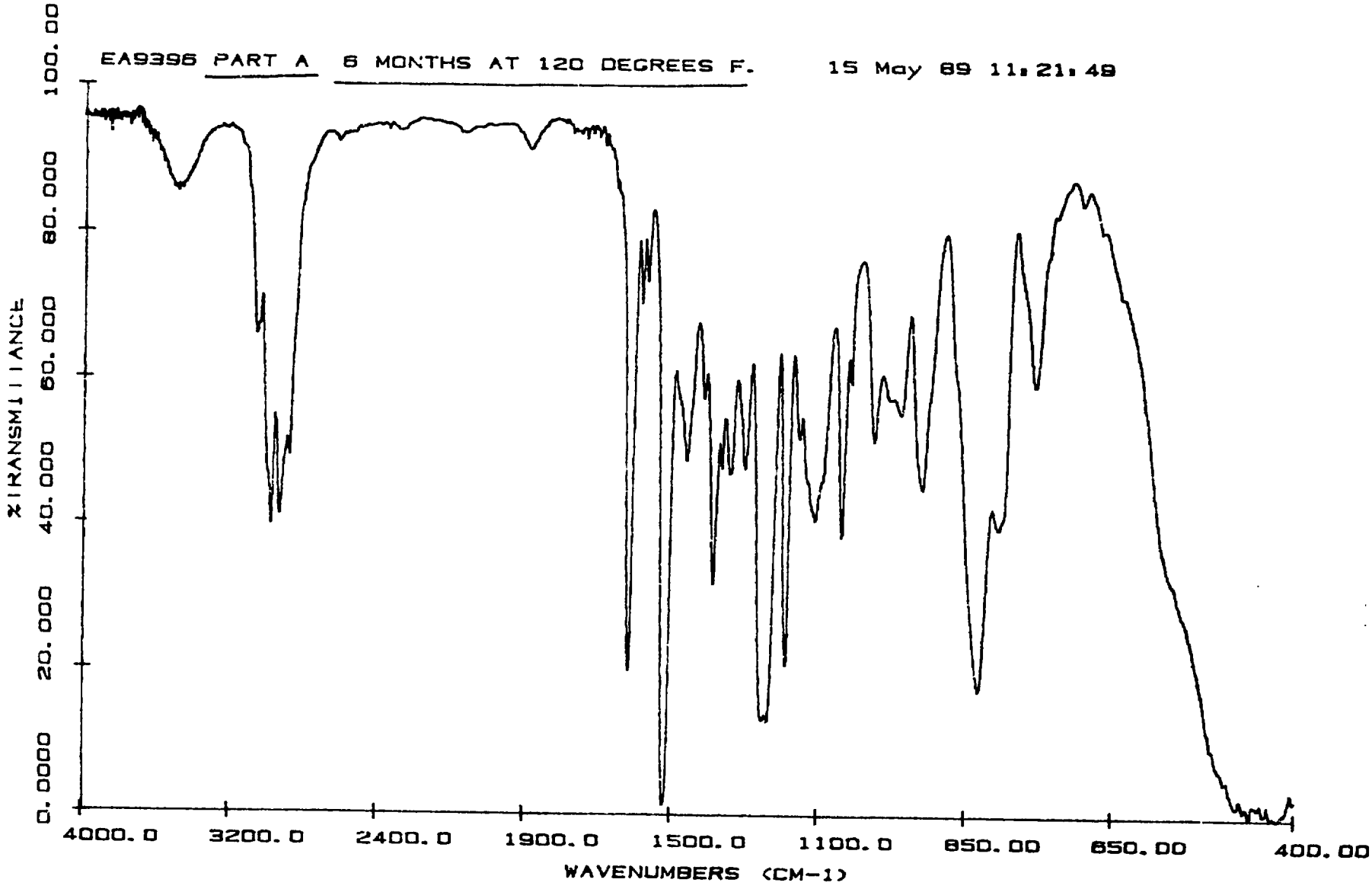


Figure M.29. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 6 Months.

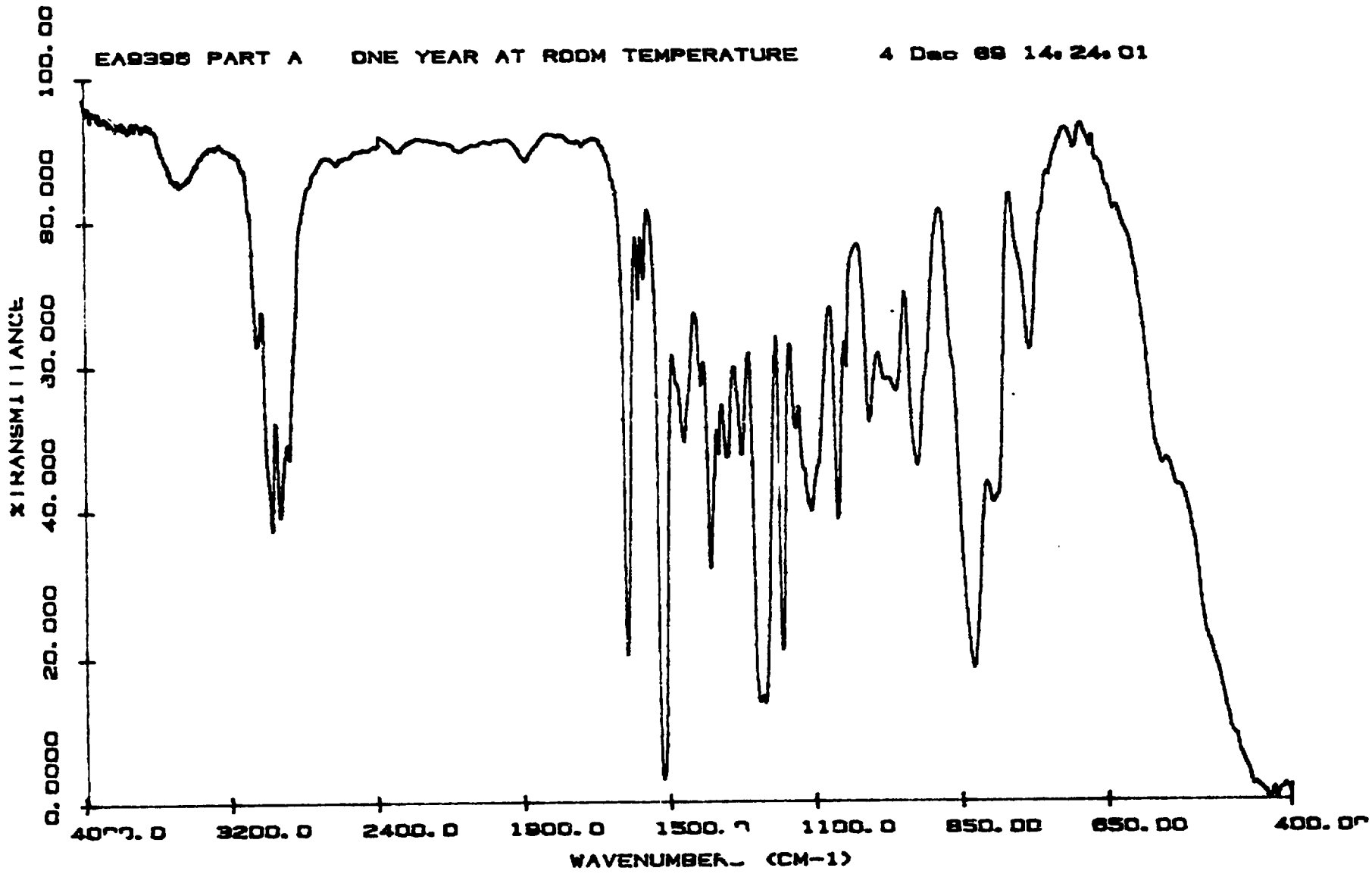


Figure M.30. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 12 Months.

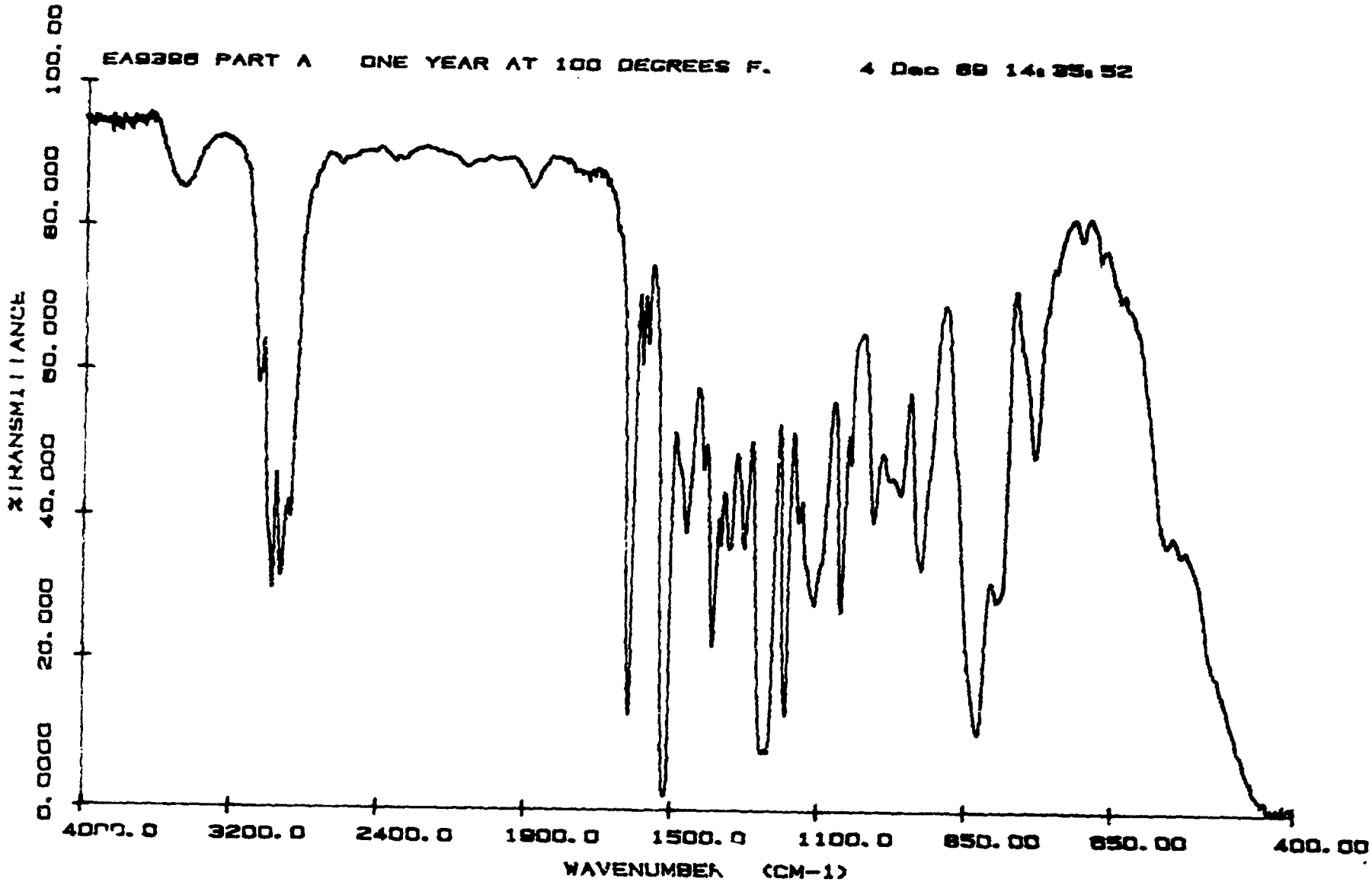


Figure M.31. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 12 Months.

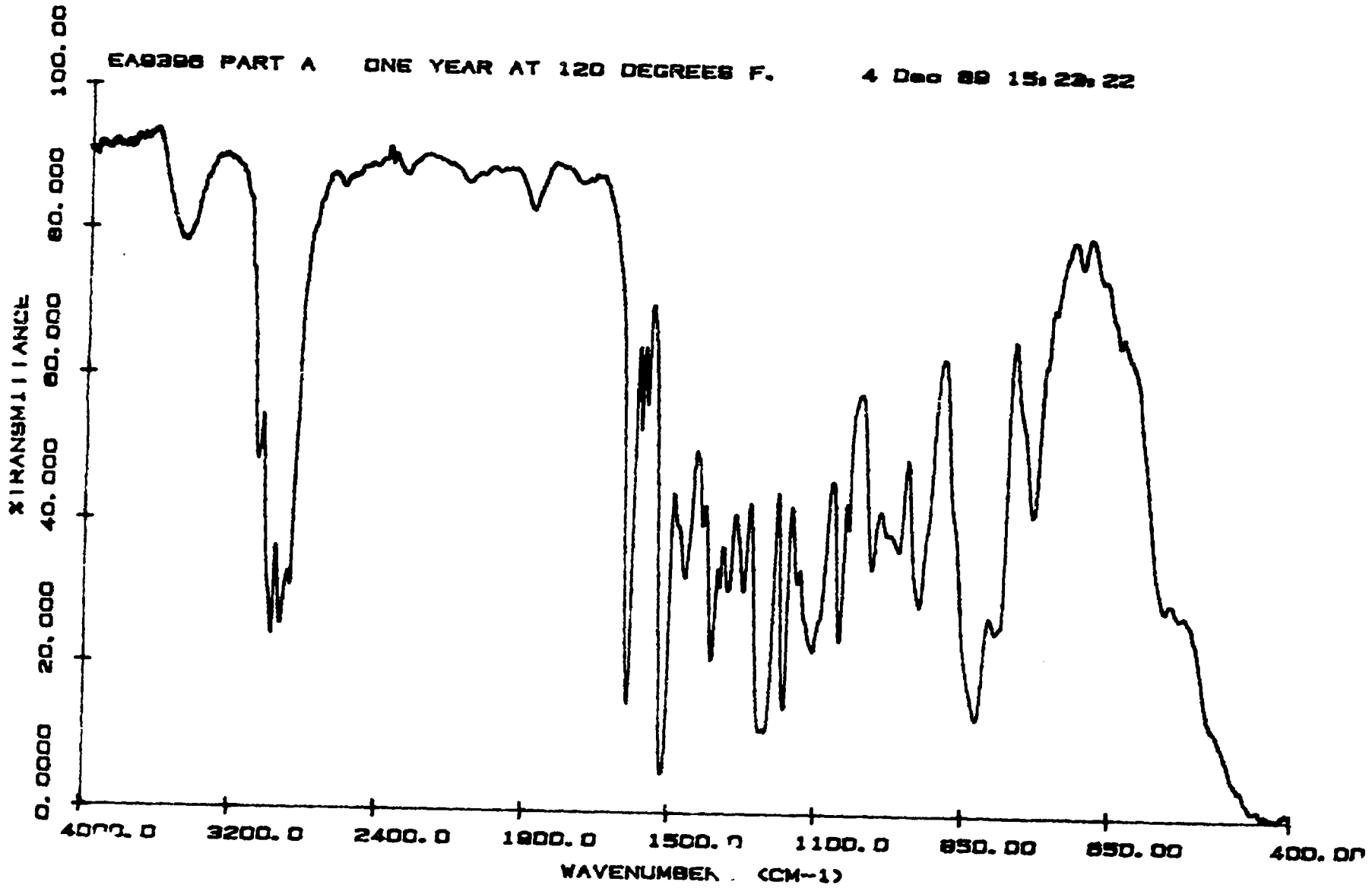


Figure M.32. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 12 Months.

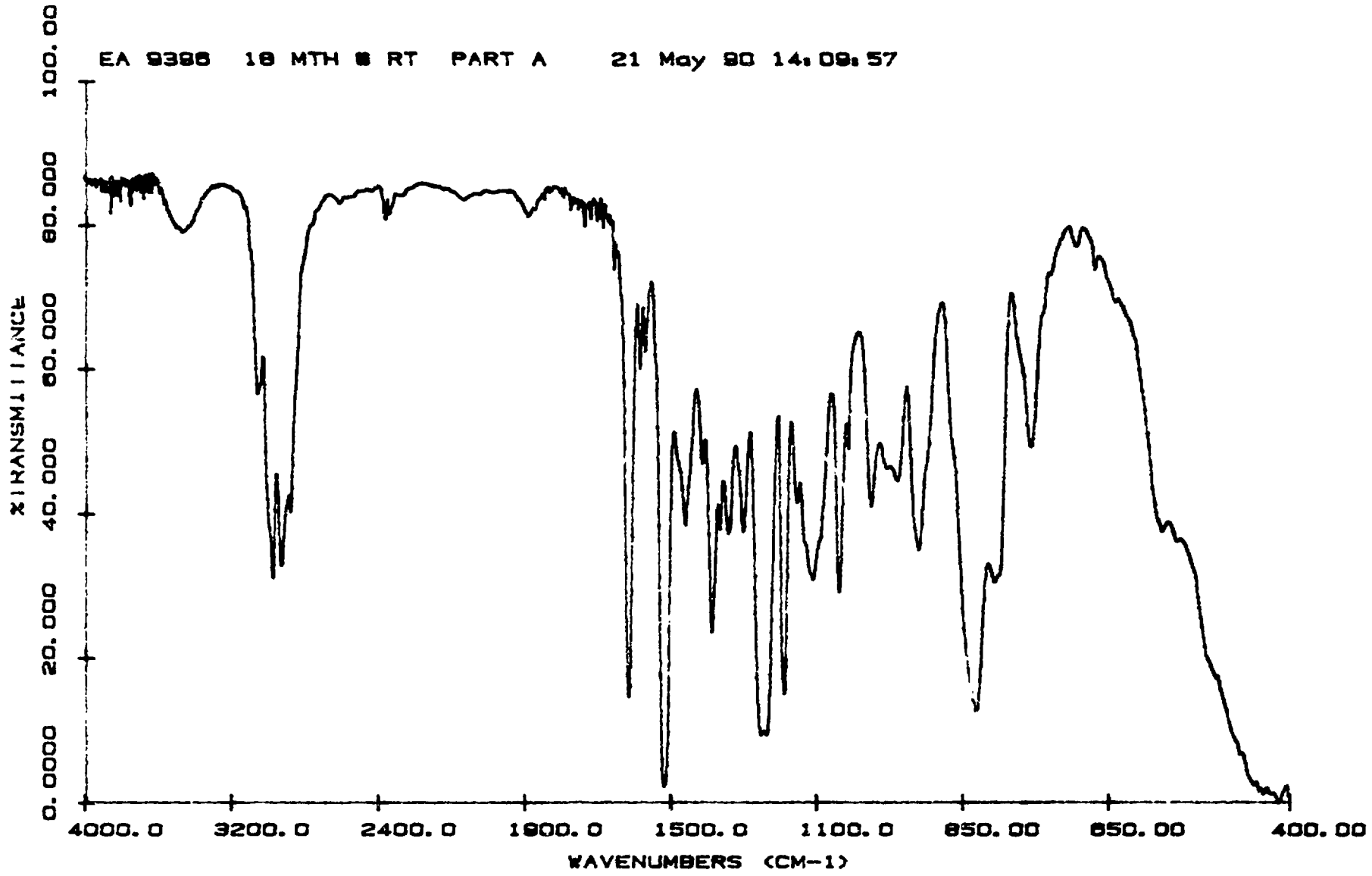


Figure M.33. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 18 Months.

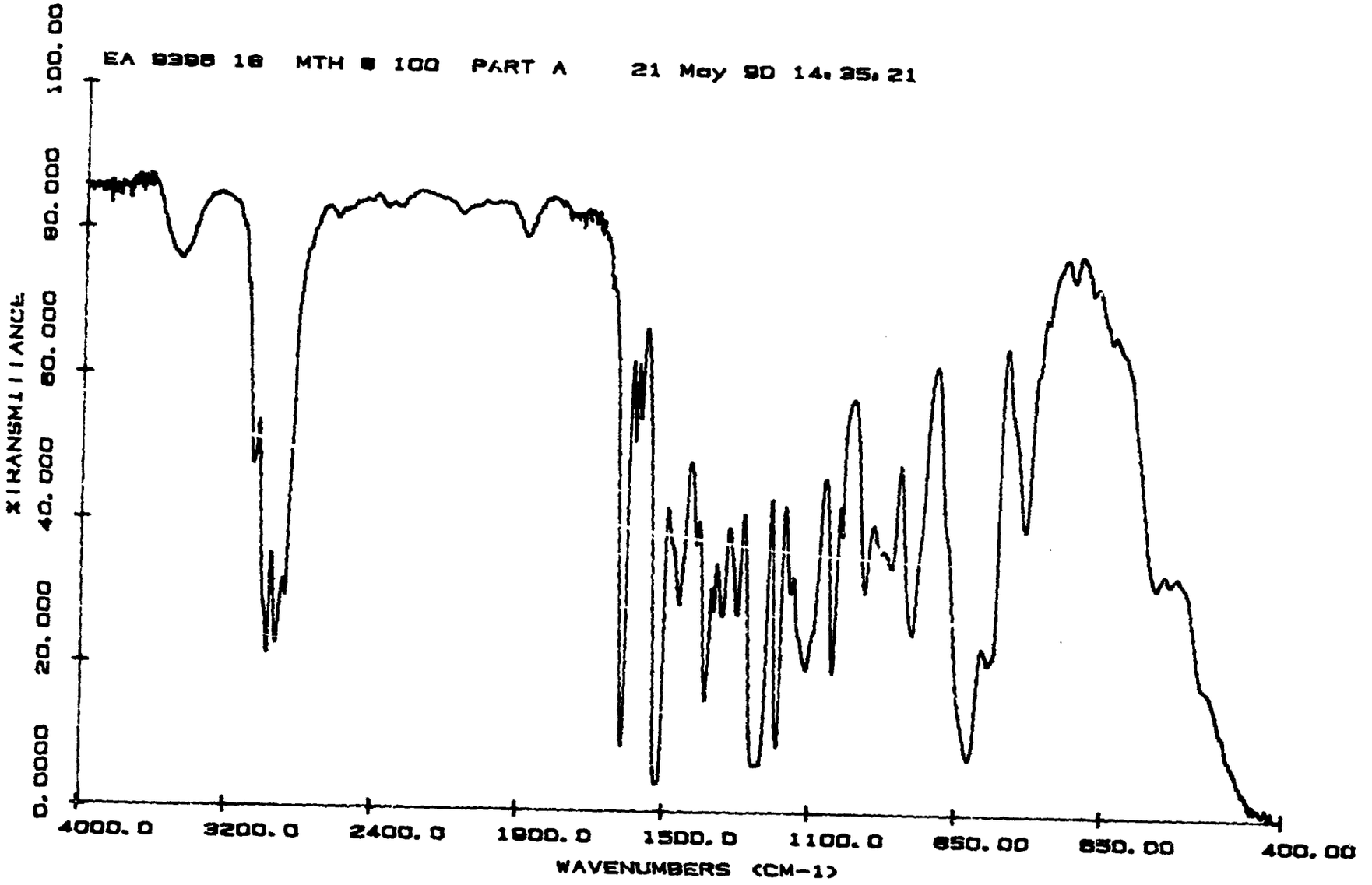


Figure M.34. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 18 Months.

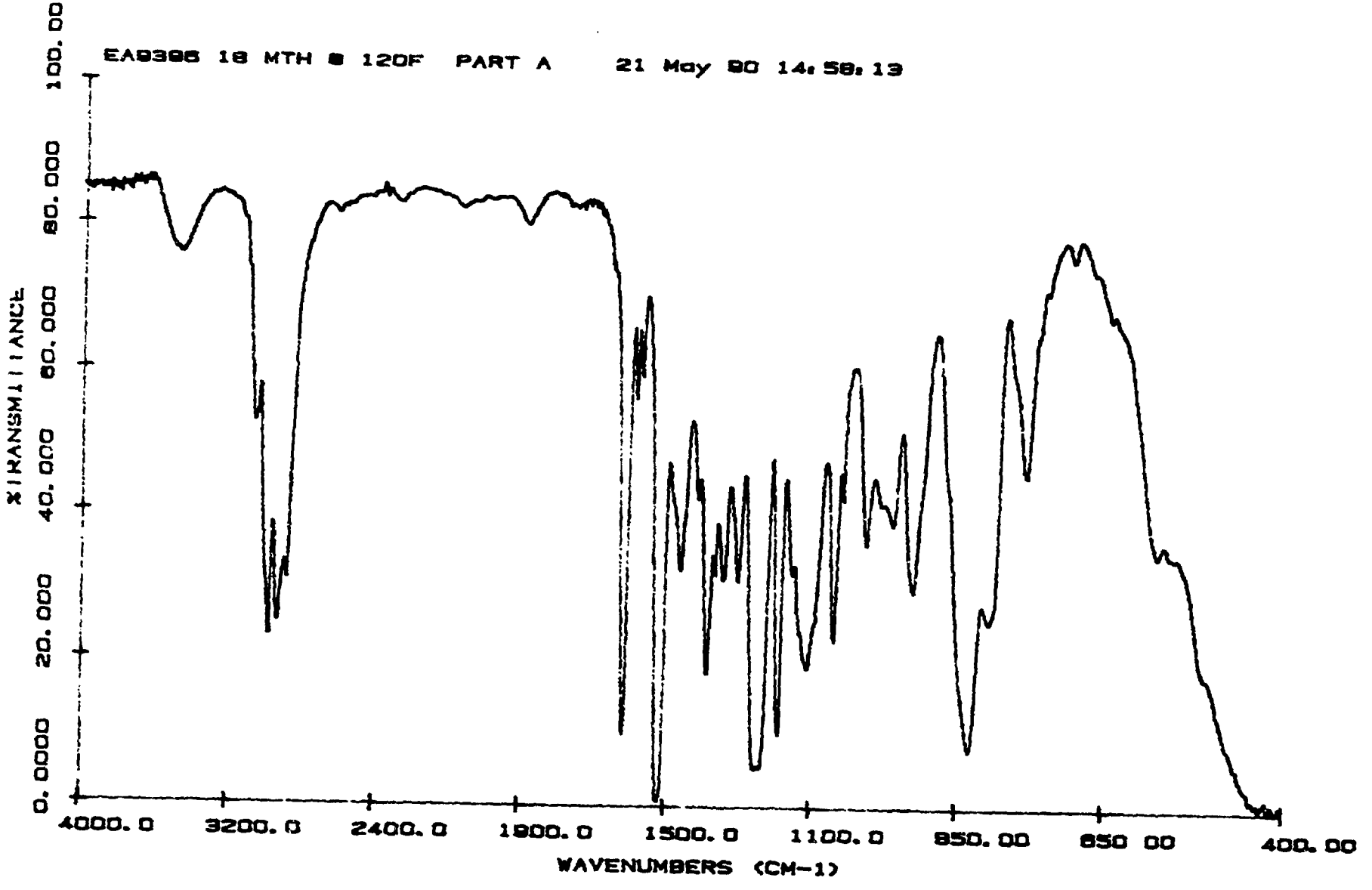


Figure M.35. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 18 Months.

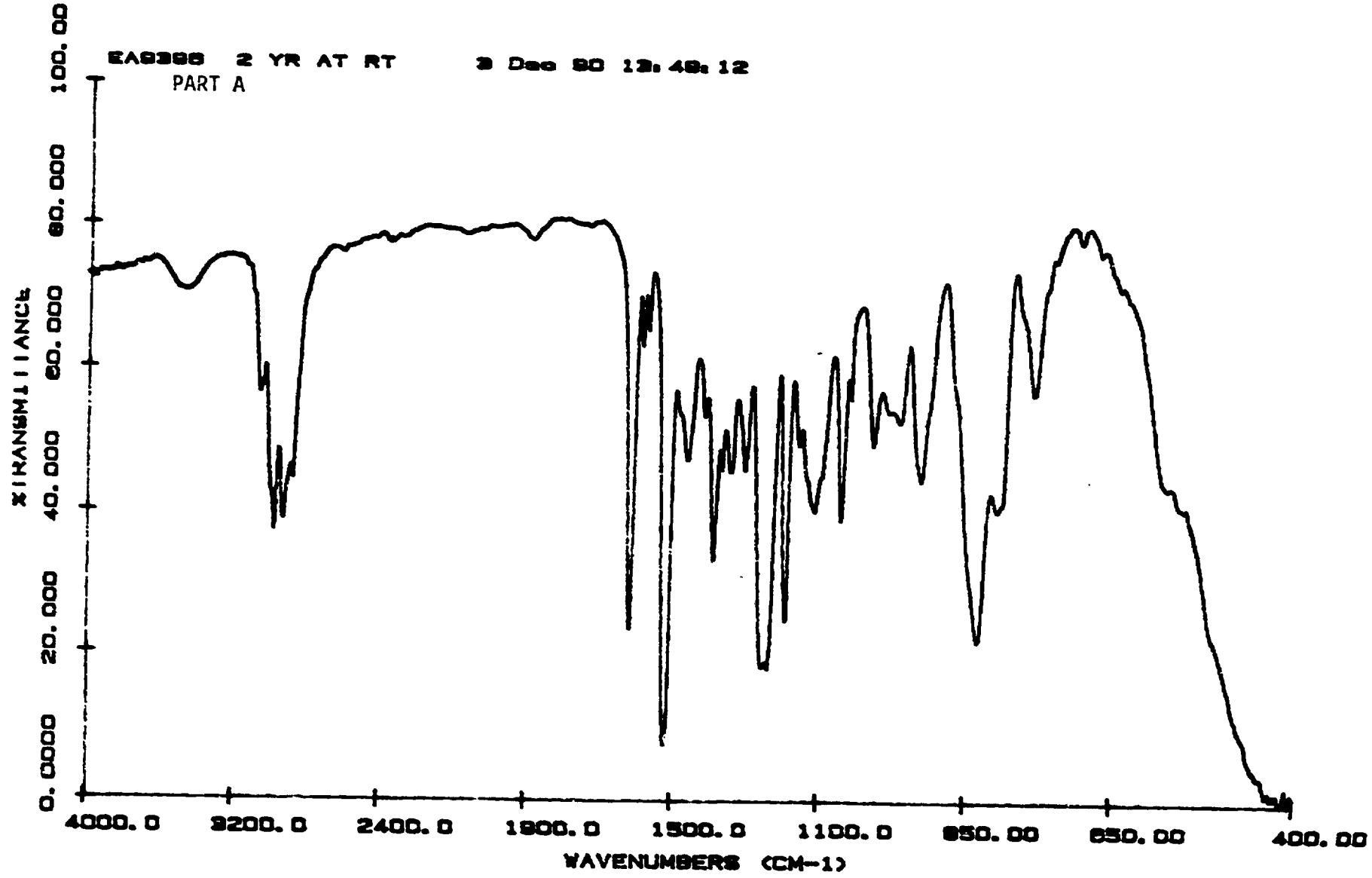


Figure M.36. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 24 Months.

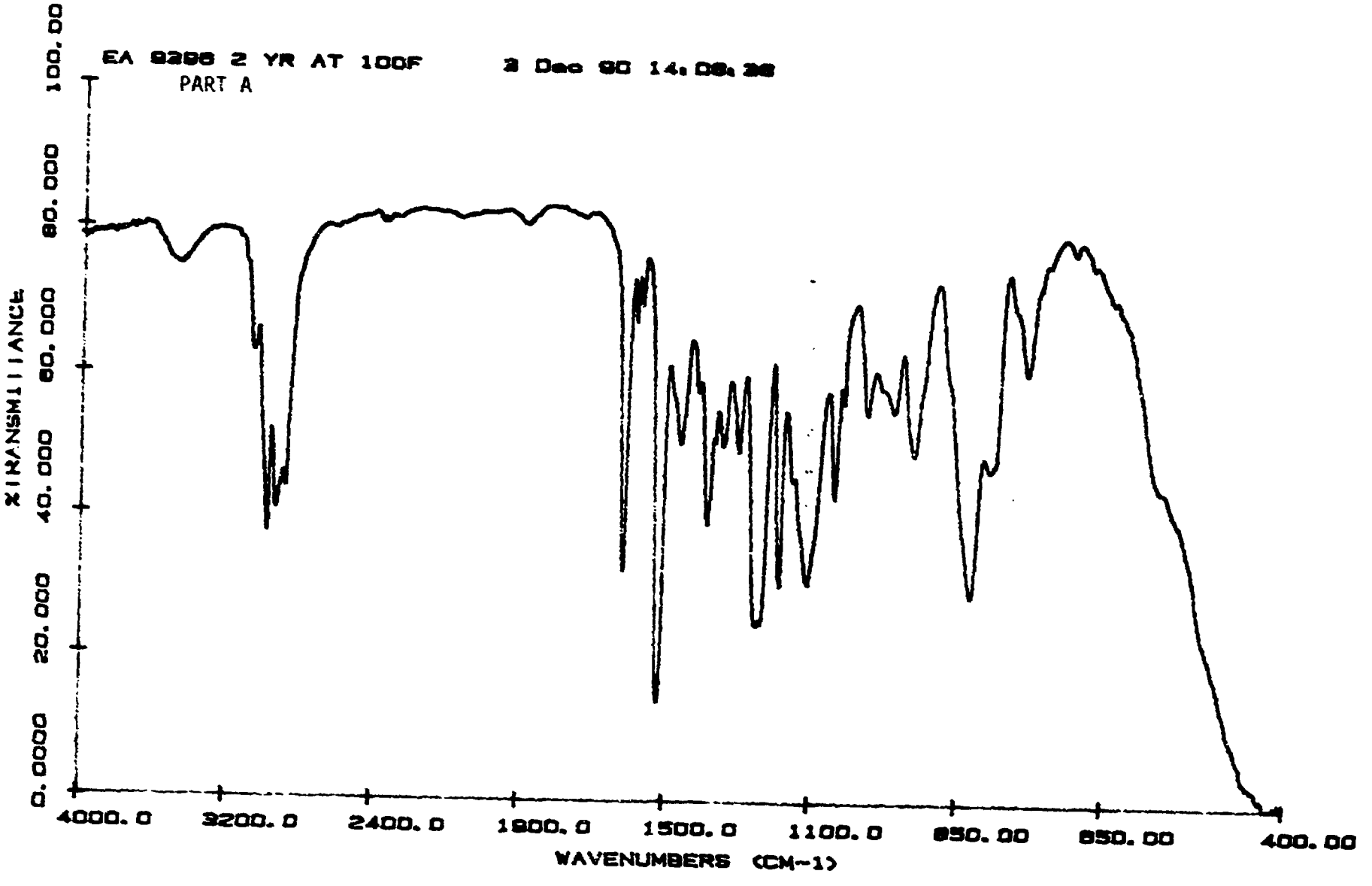


Figure M.37. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 24 Months.

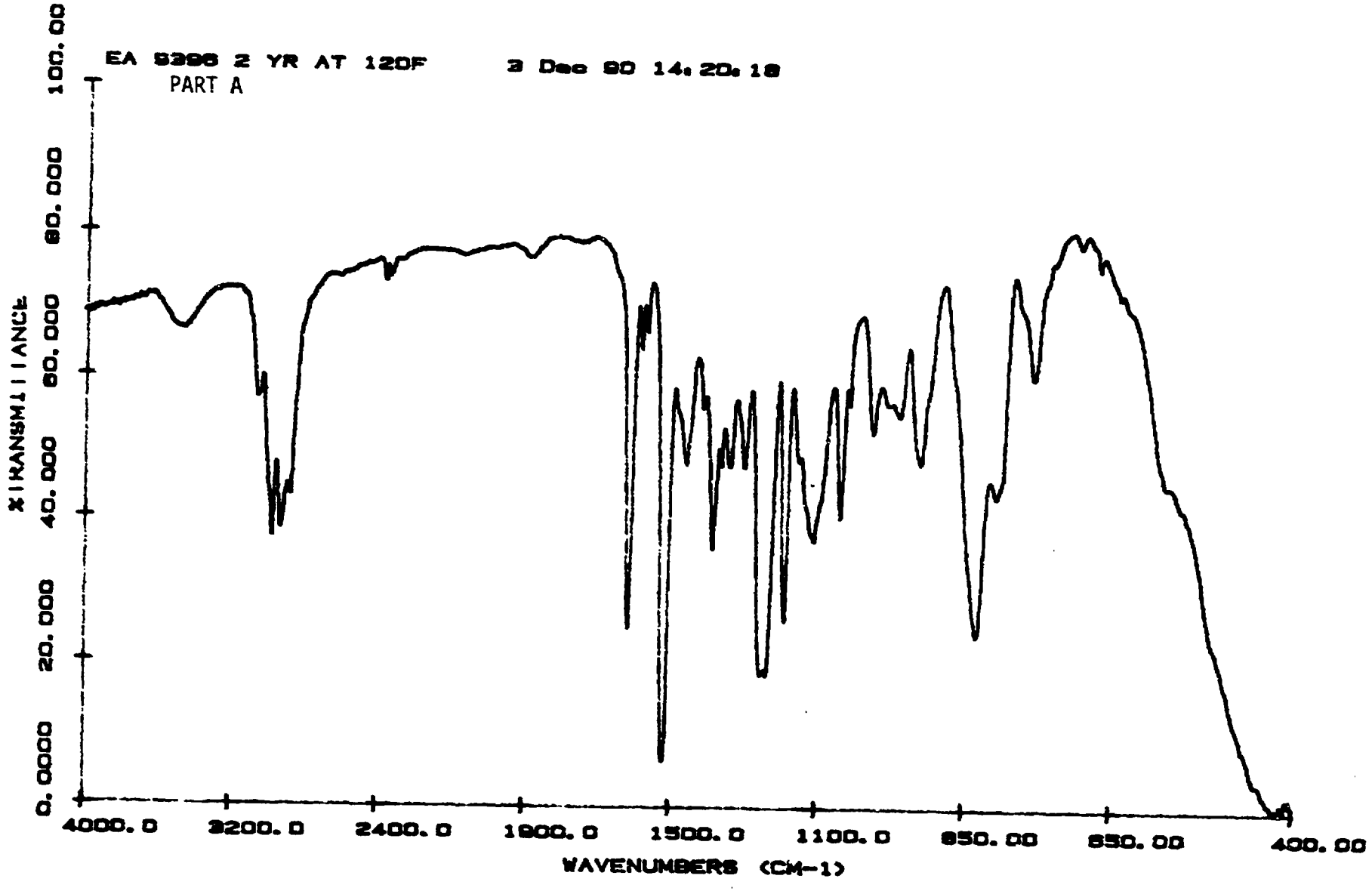


Figure M.38. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 24 Months.

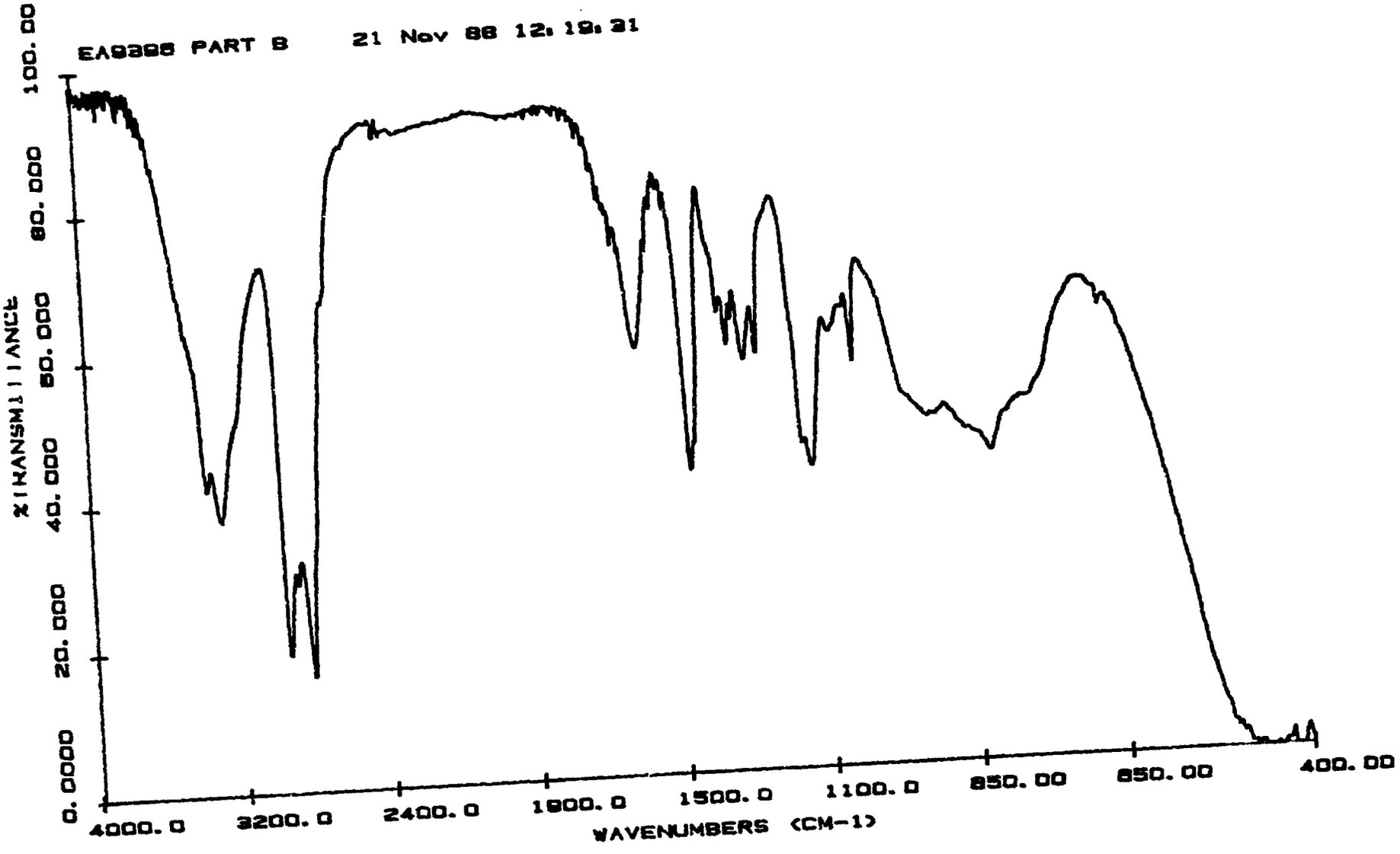


Figure M.39. FTIR Spectra for EA9396, Part B, Initial.

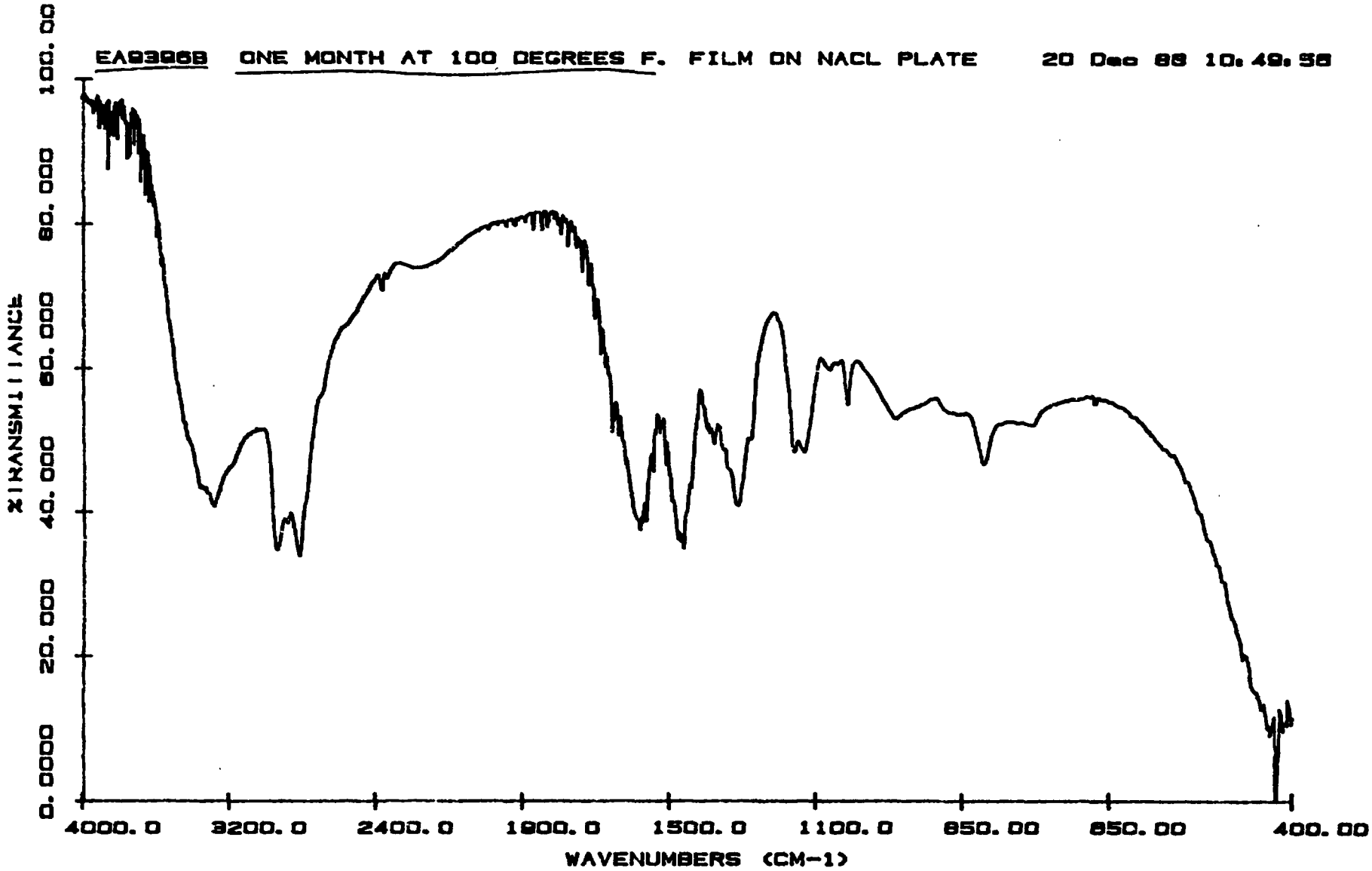


Figure M.40. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 1 Month.

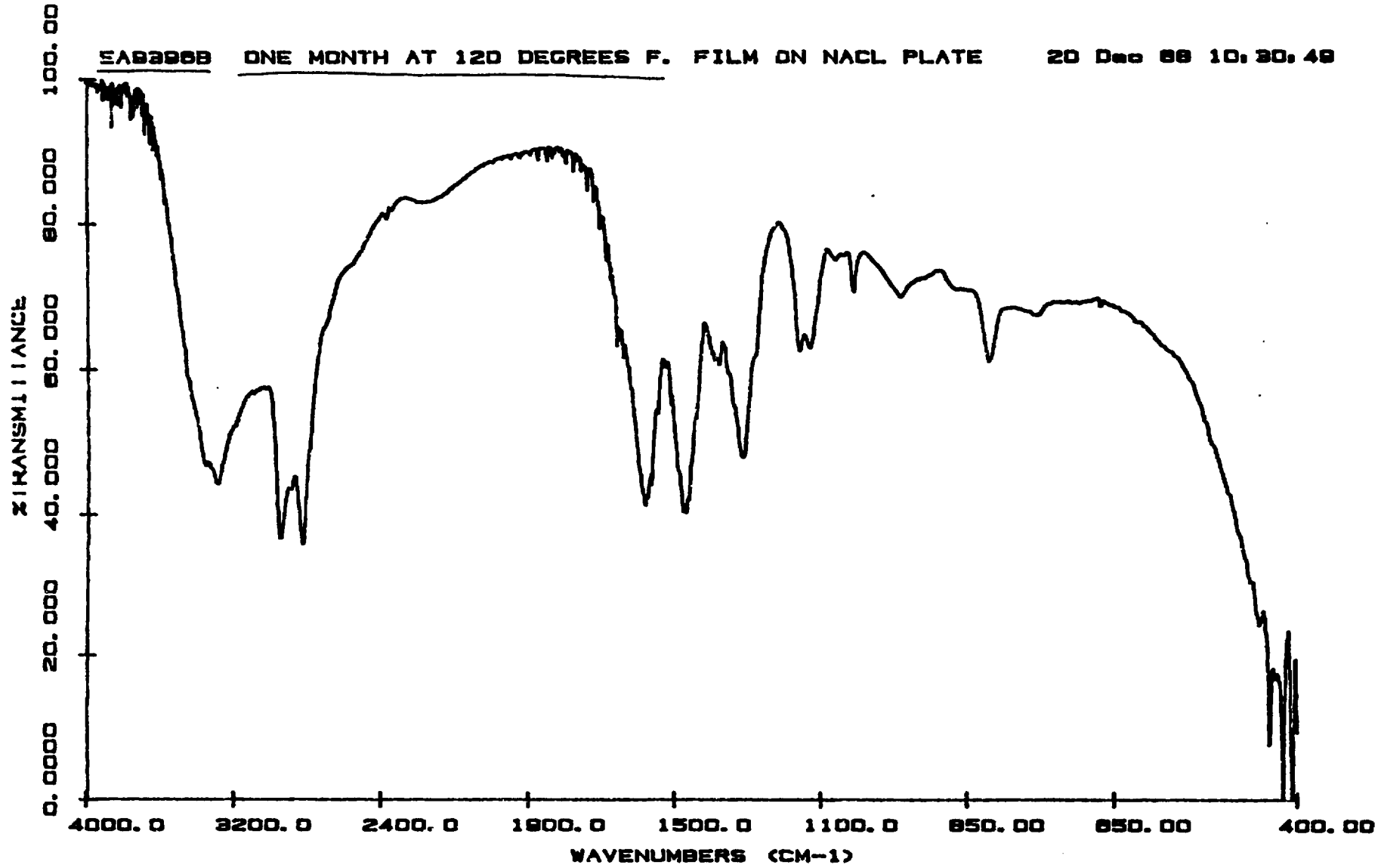


Figure M.41. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 1 Month.

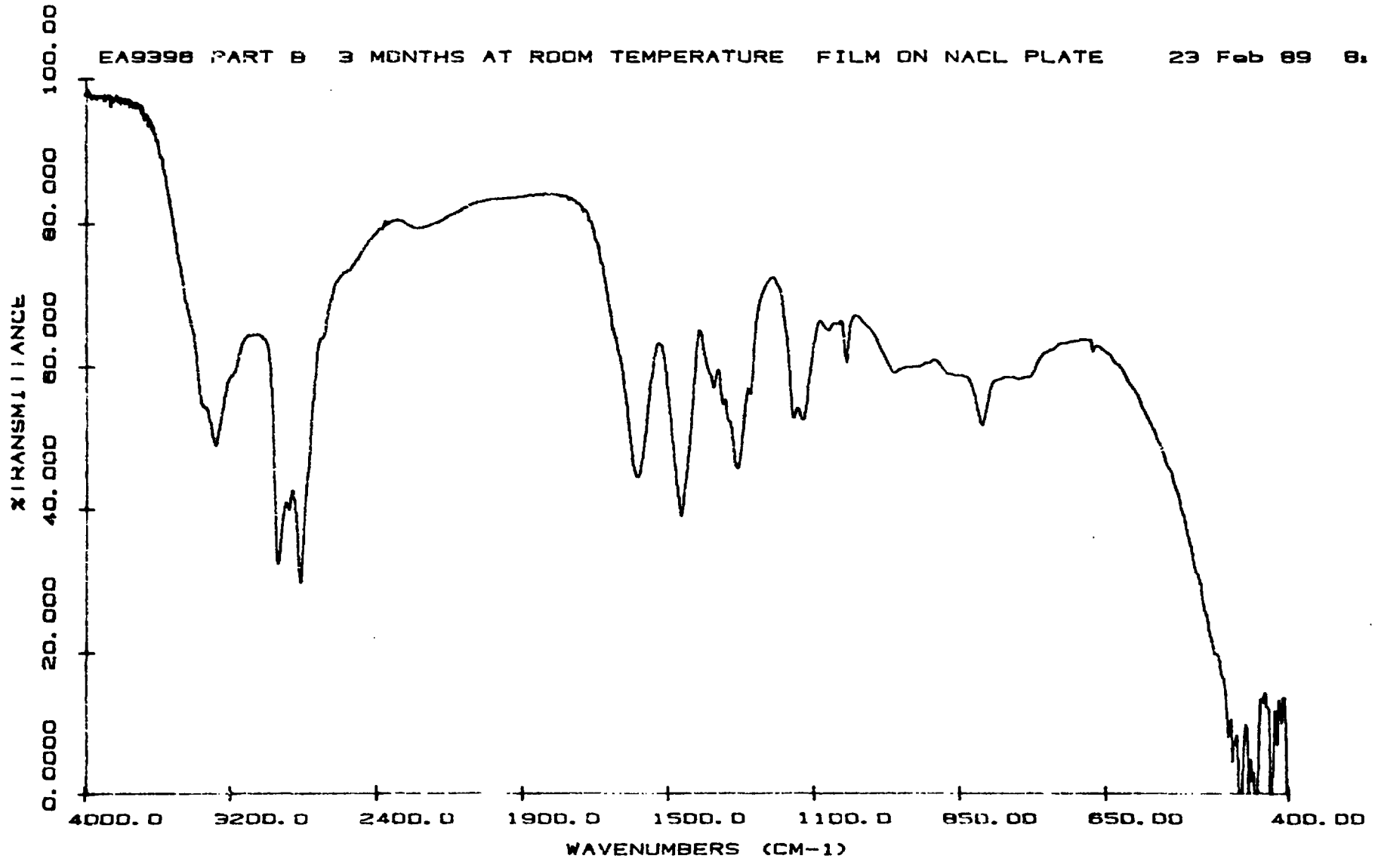


Figure M.42. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 3 Months.

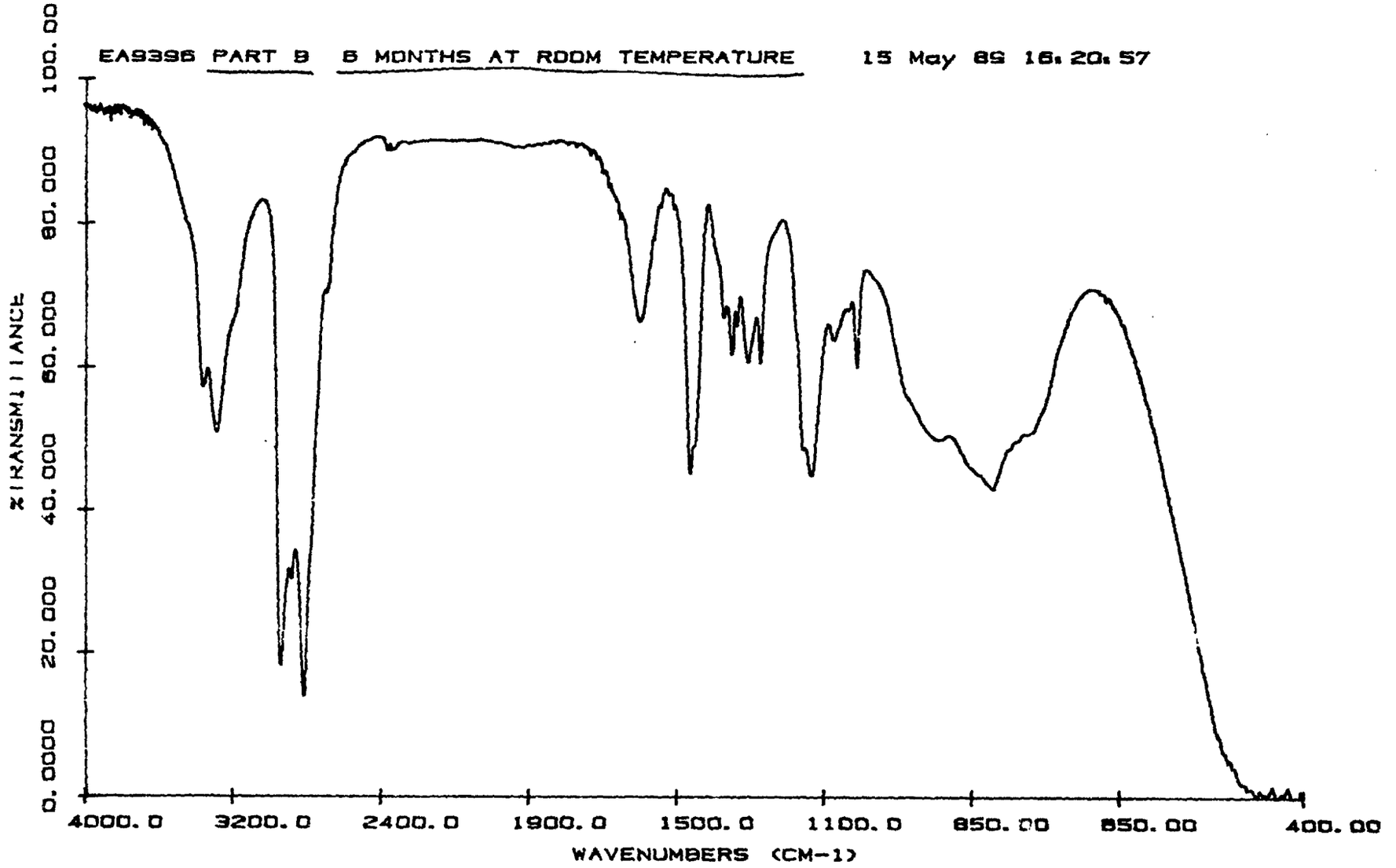


Figure M.43. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 6 Months.

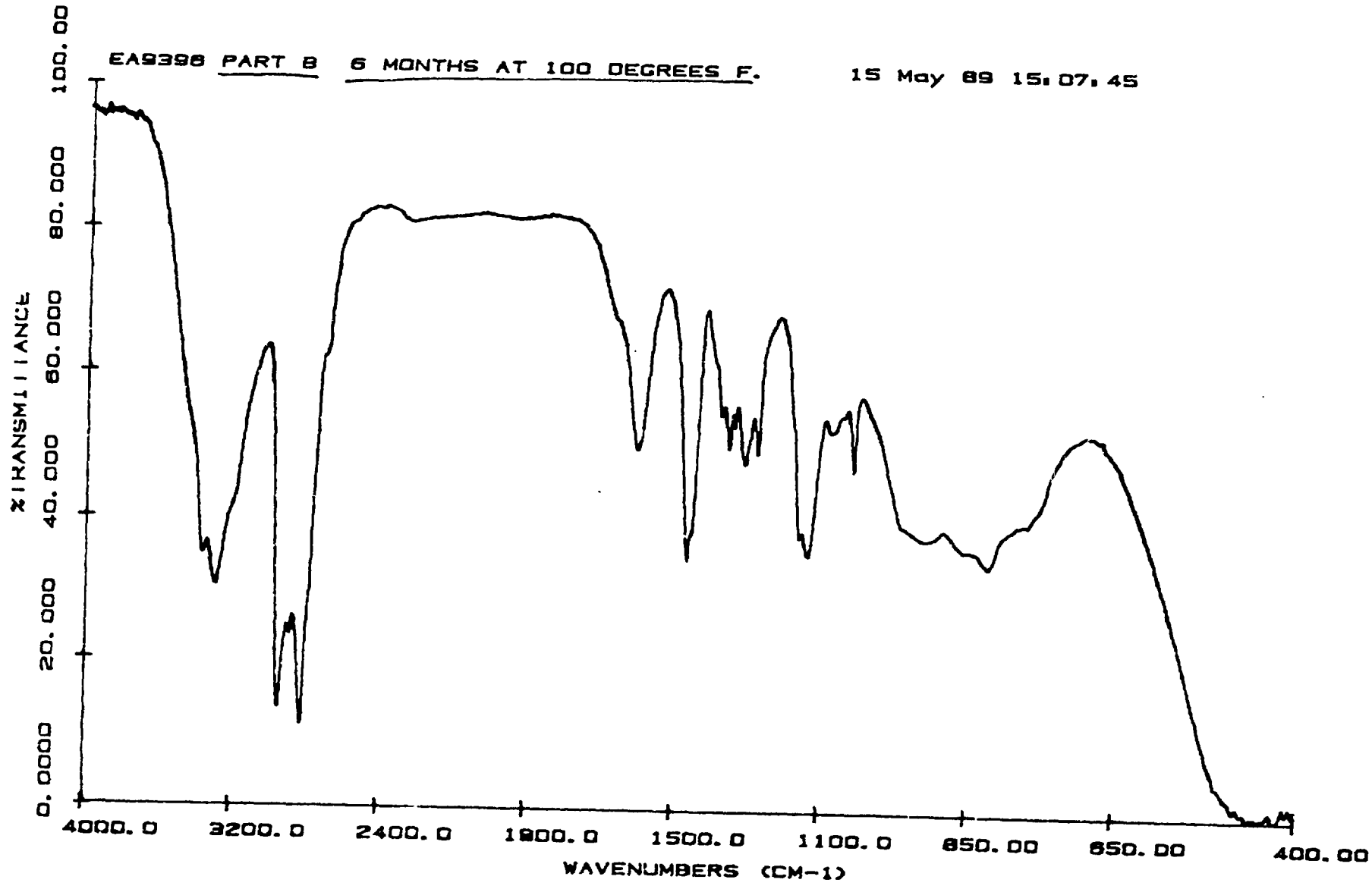


Figure M.44. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 6 Months.

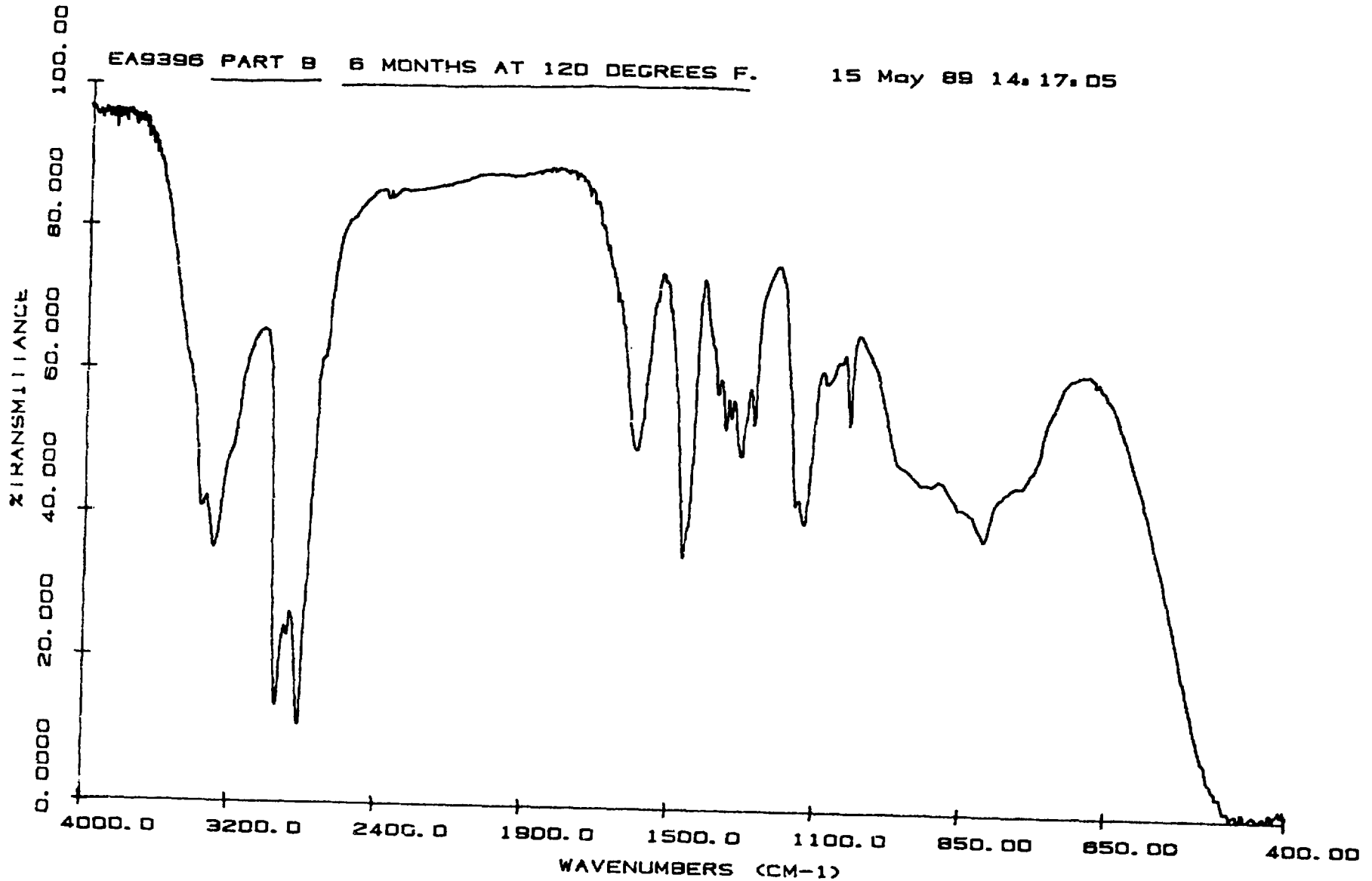


Figure M.45. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 6 Months.

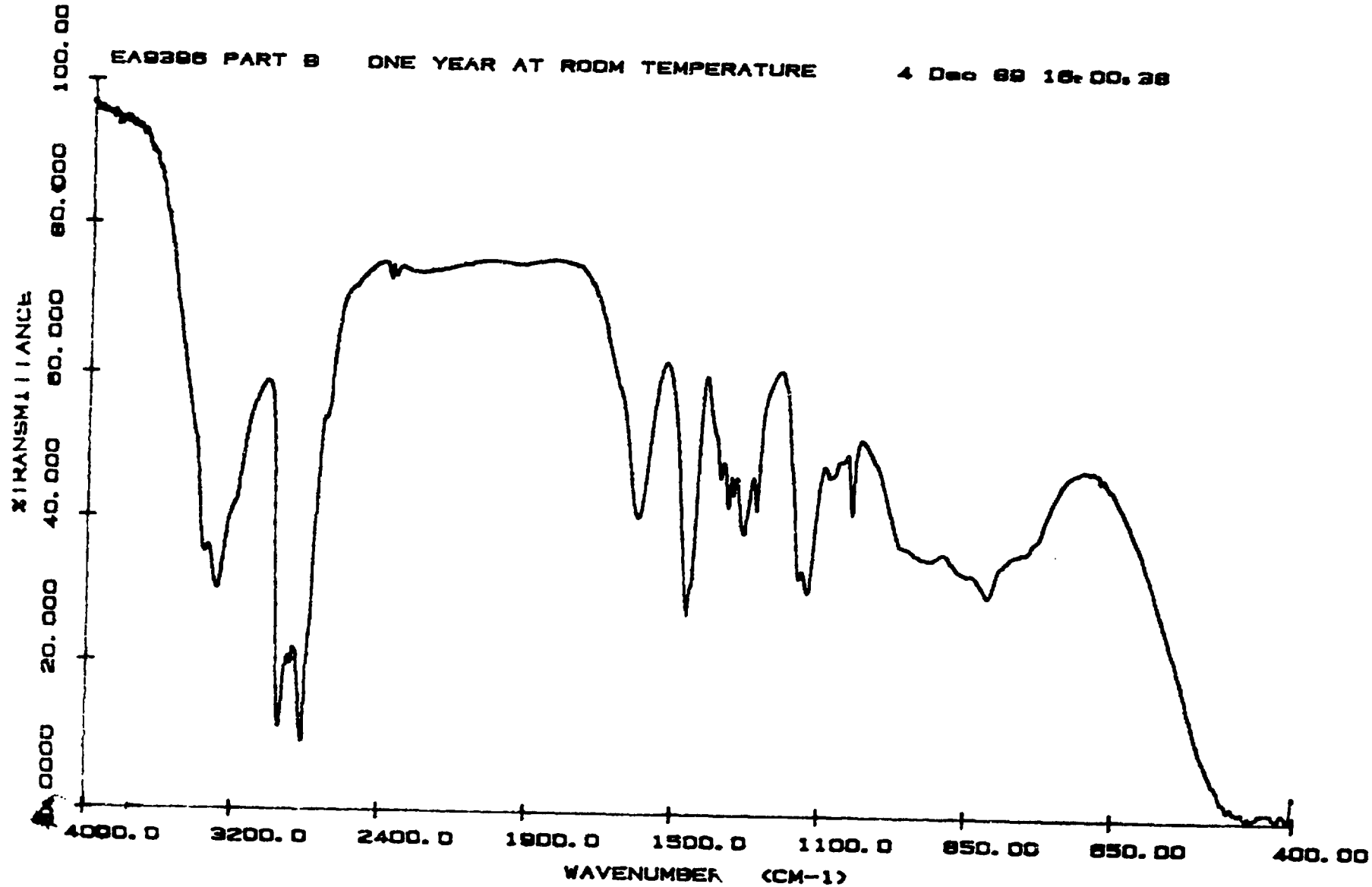


Figure M.46. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 12 Months.

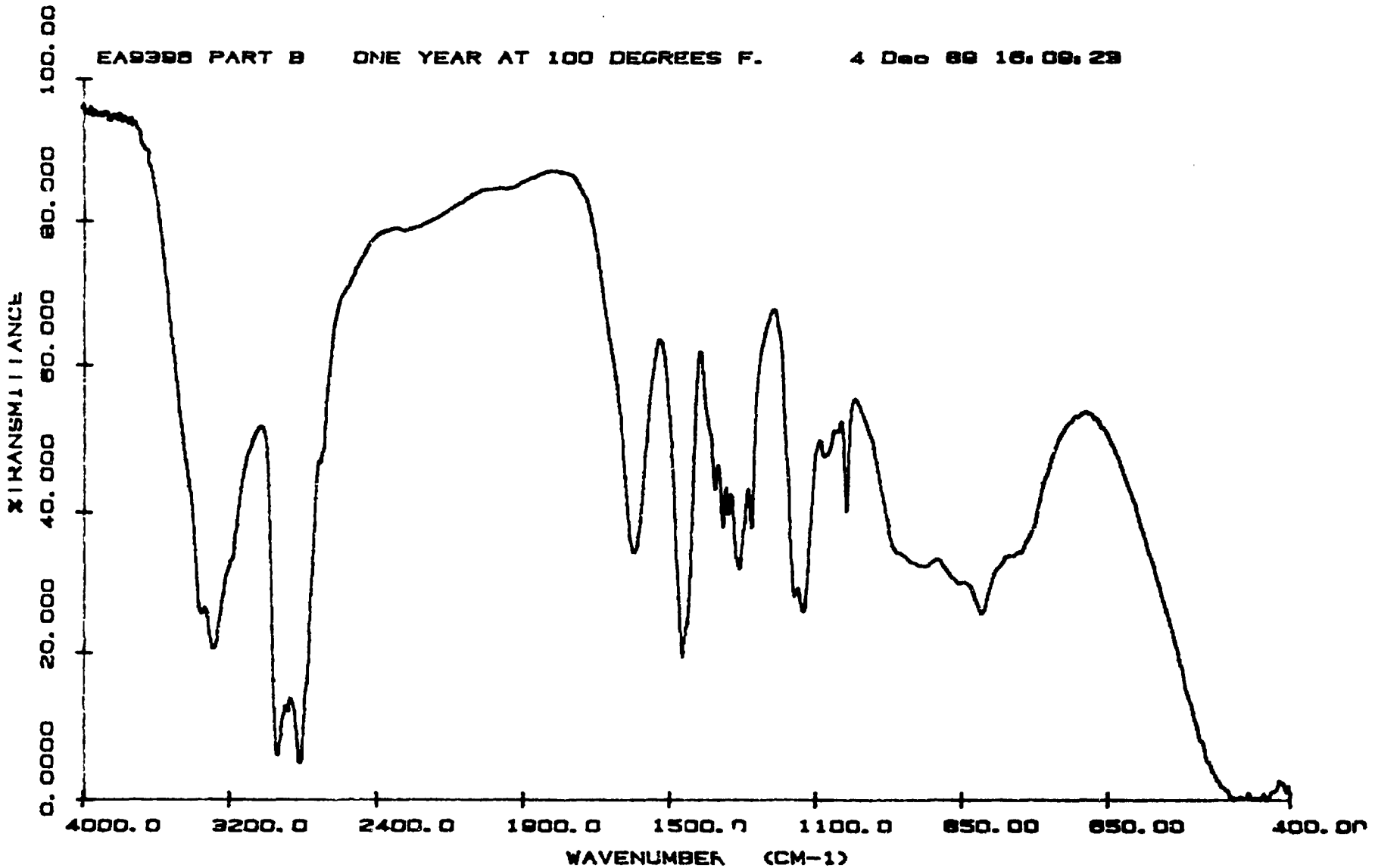


Figure M.47. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 12 Months.

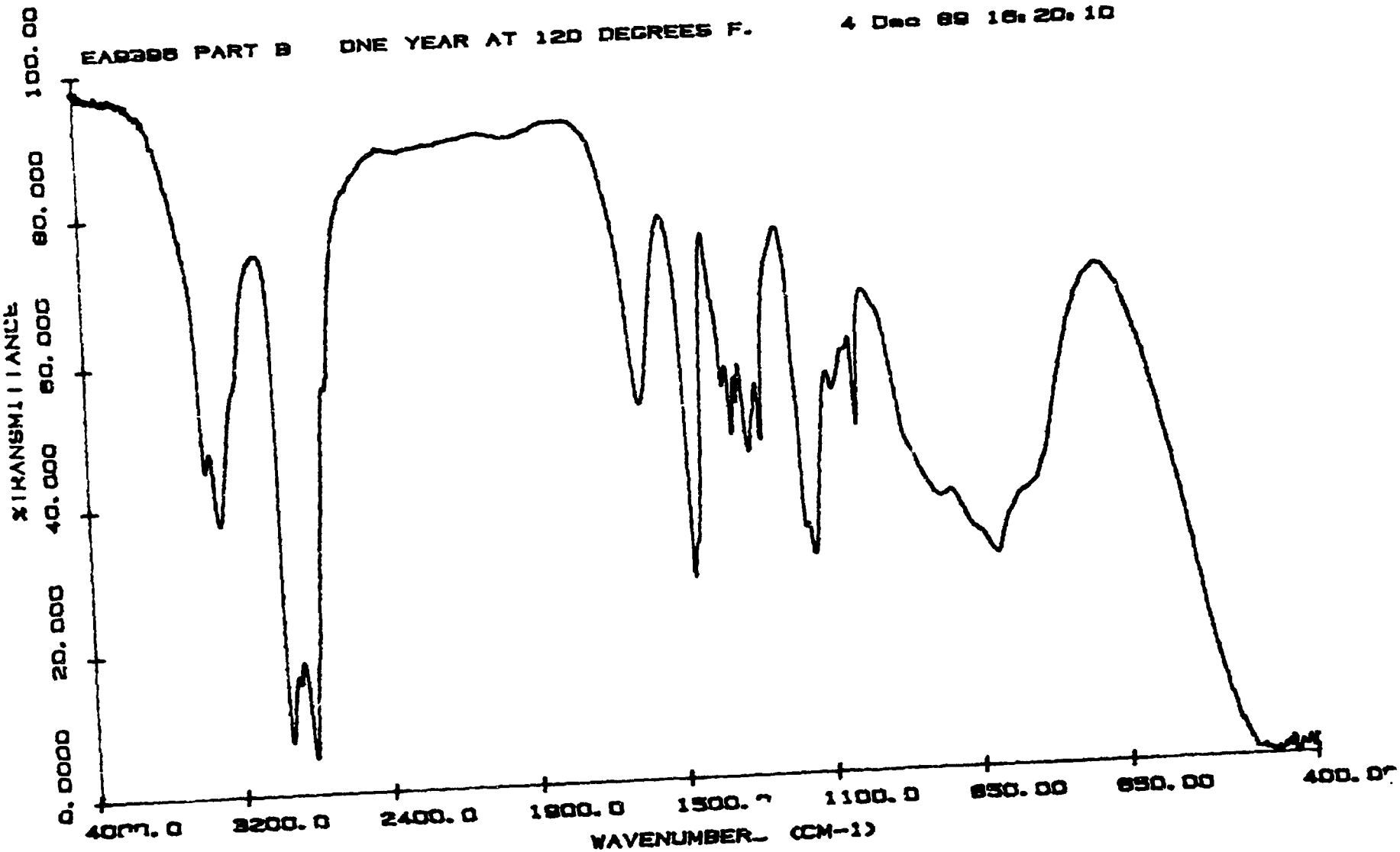


Figure M.48. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 12 Months.

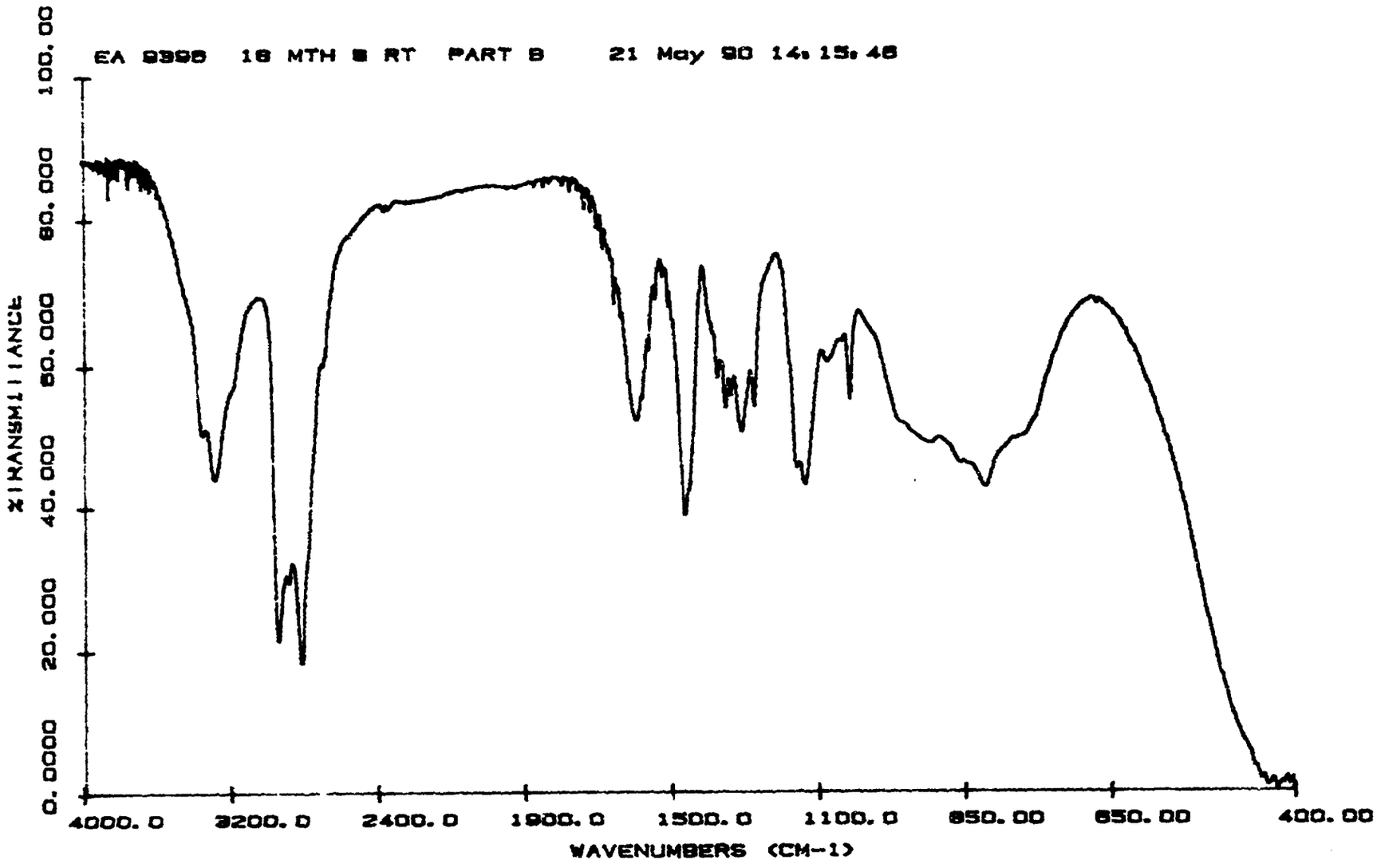


Figure M.49. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 18 Months.

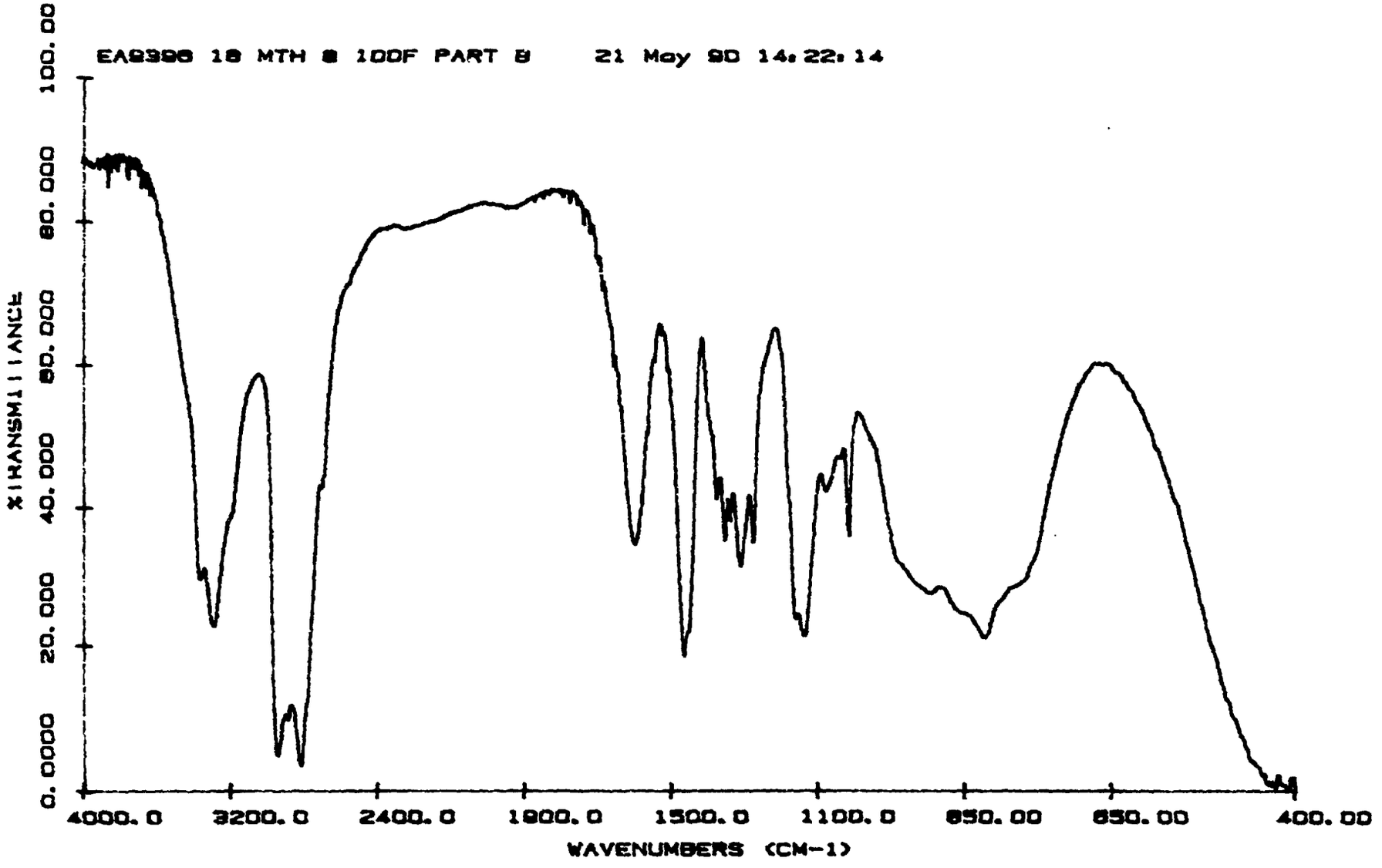


Figure M.50. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 18 Months.

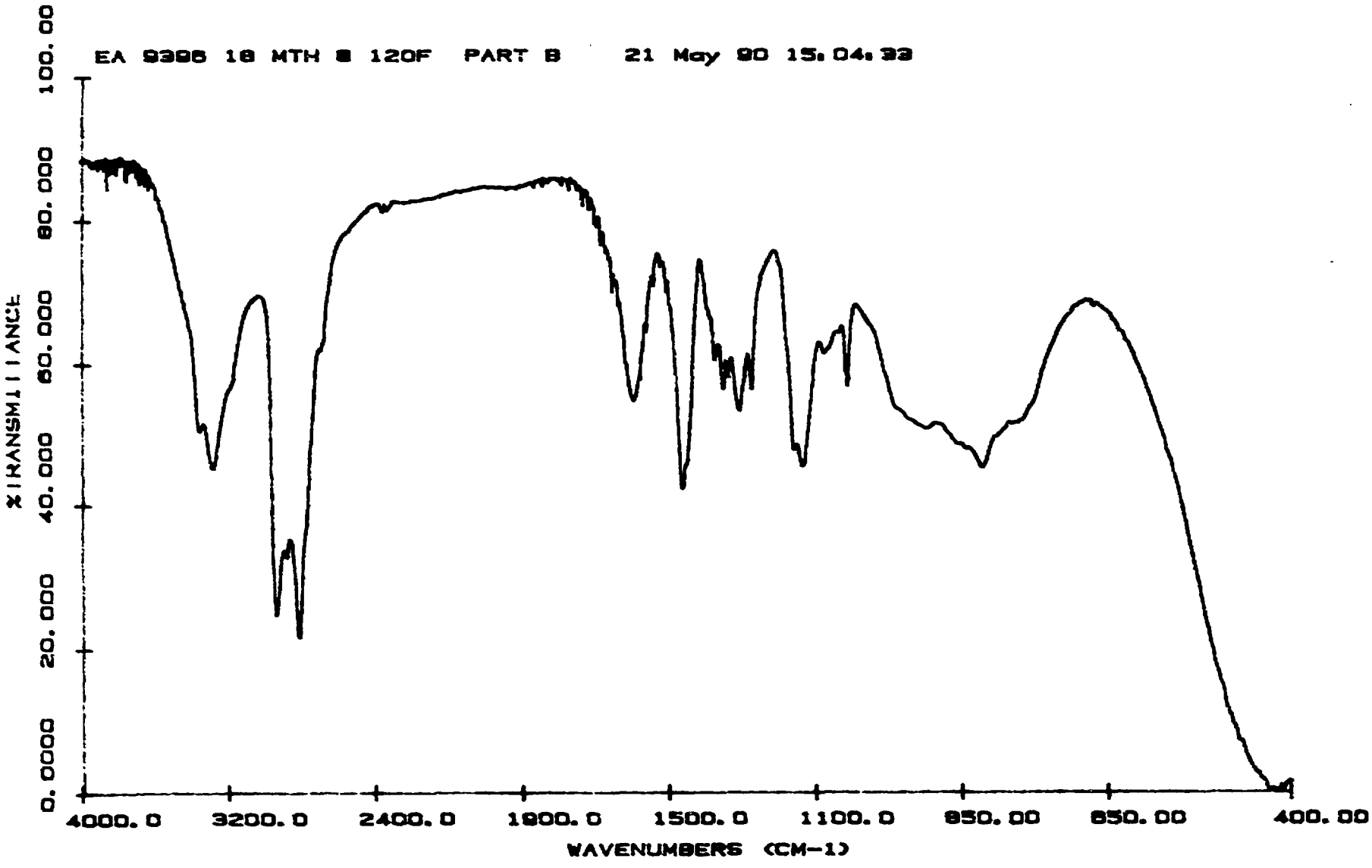


Figure M.51. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 18 Months.

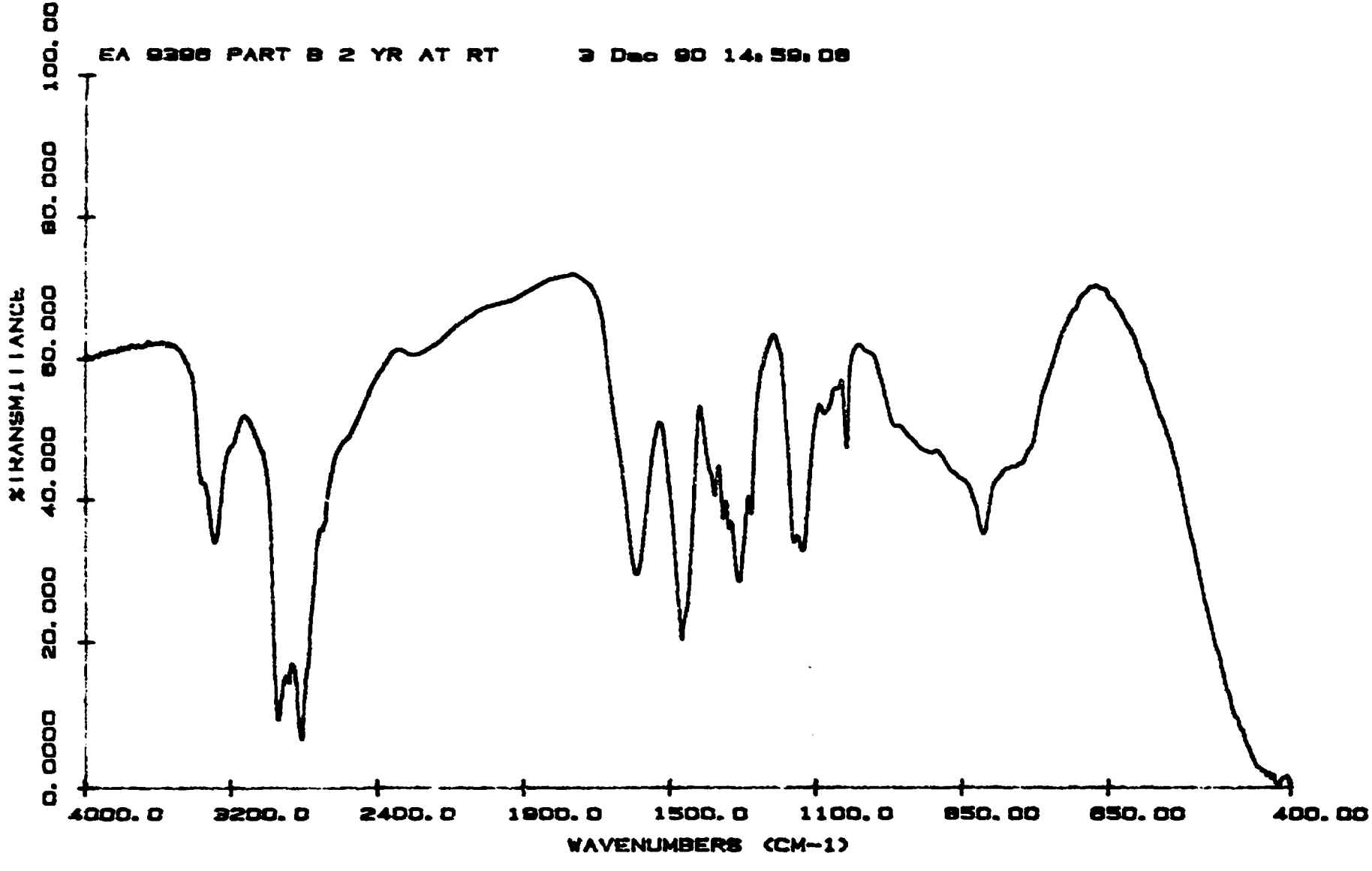


Figure M.52. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 24 Months.

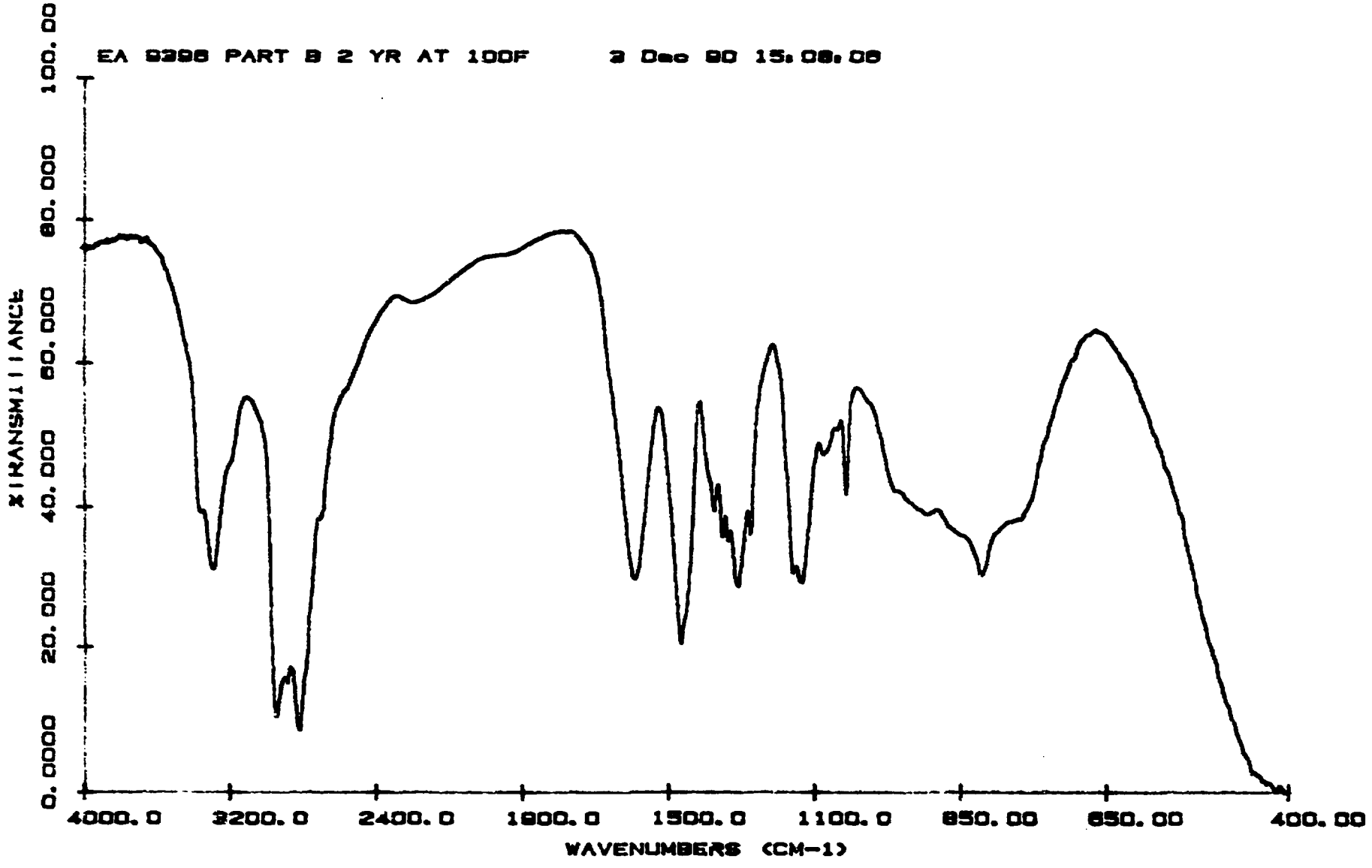


Figure M.53. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 24 Months.

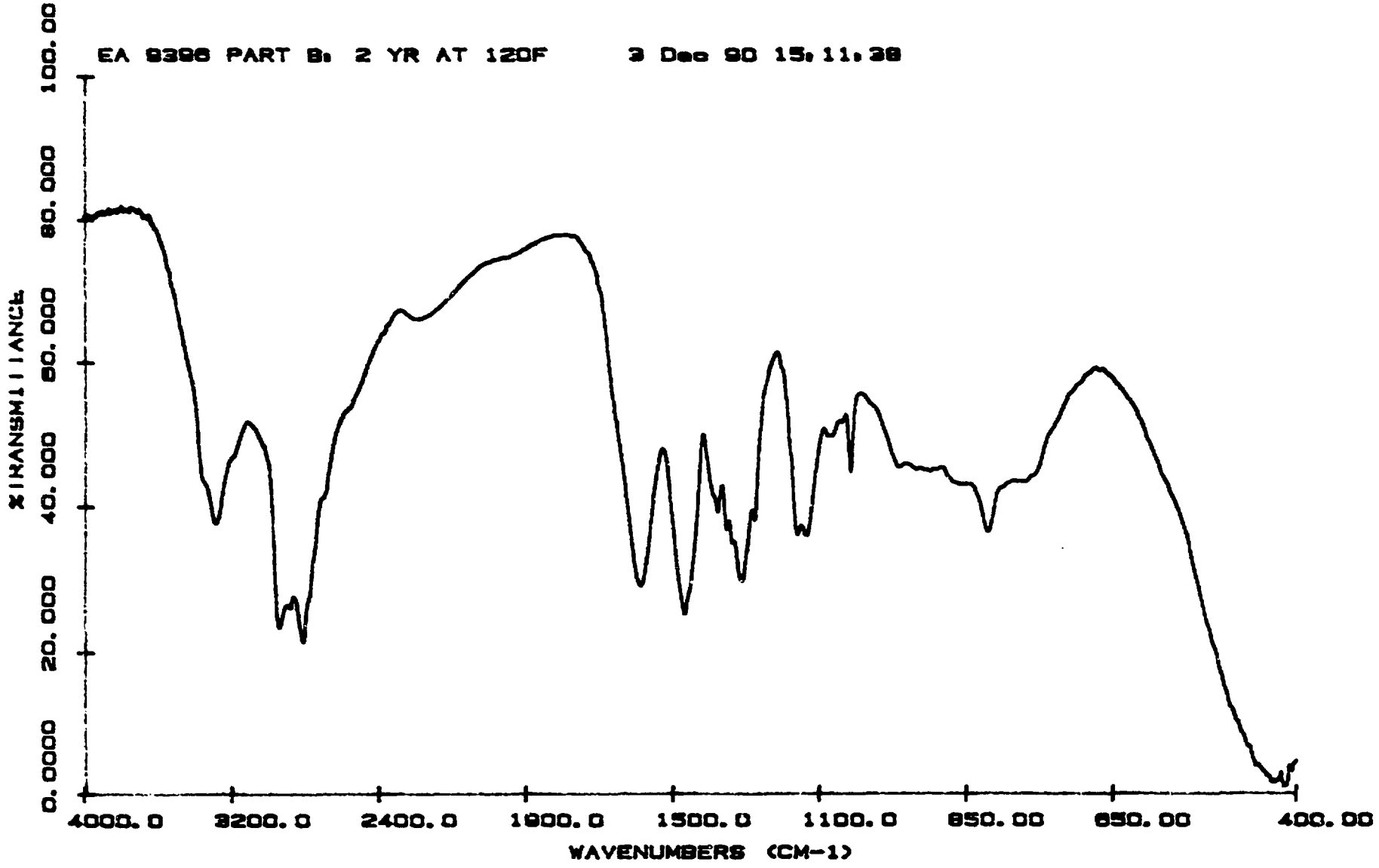


Figure M.54. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 24 Months.

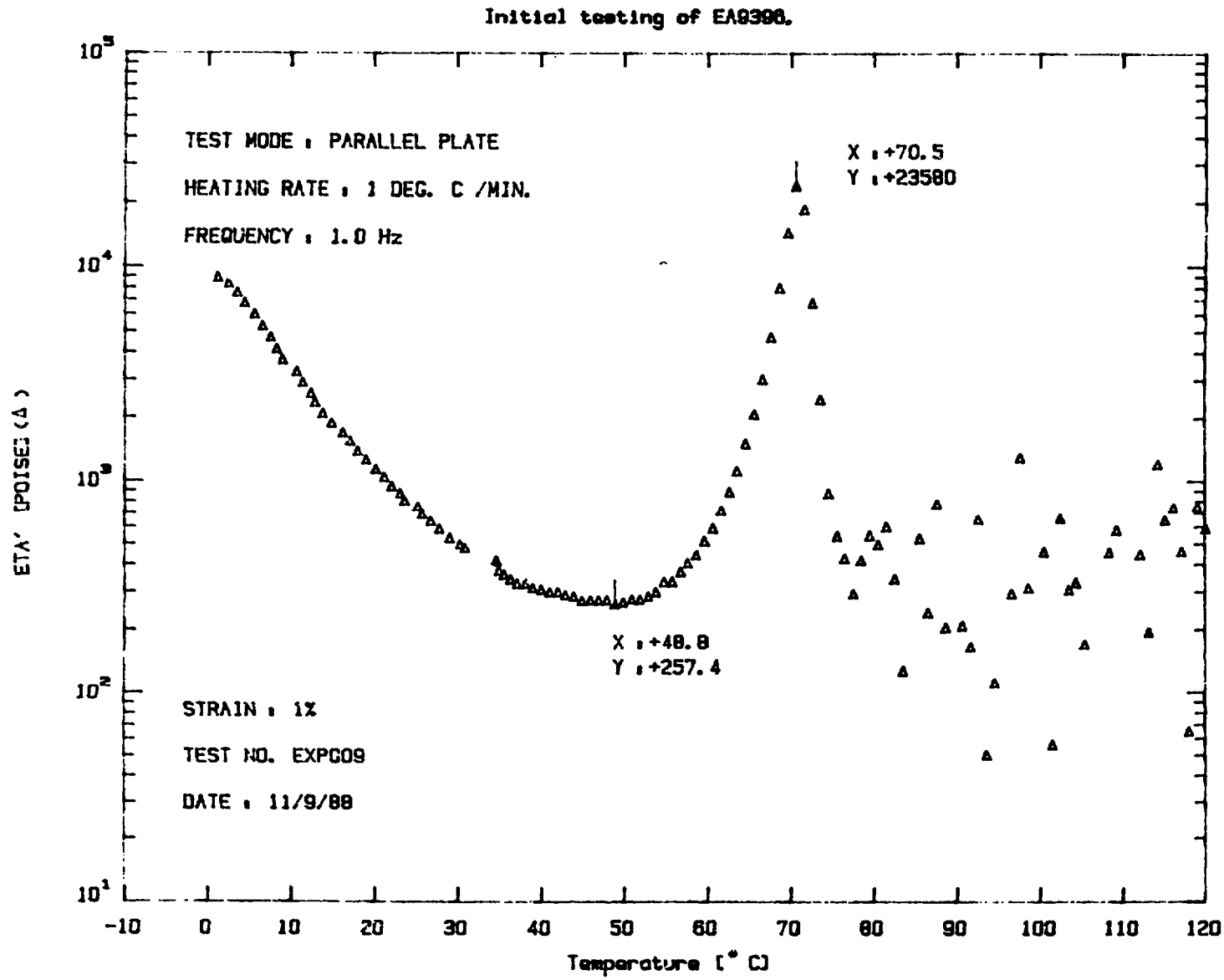


Figure M.55. Viscosity Cure Profile for EA9396, Initial.

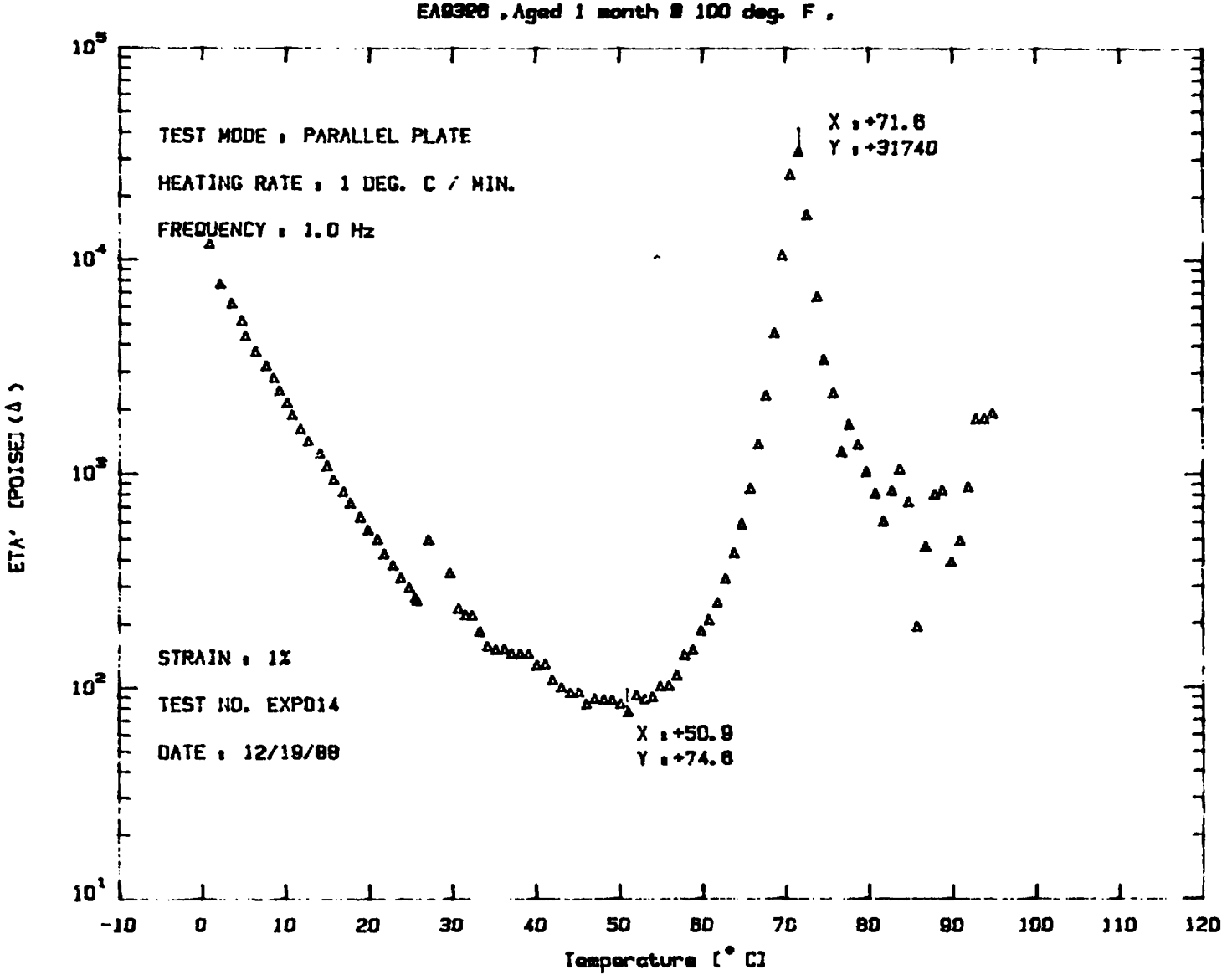


Figure M.56. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 1 Month.

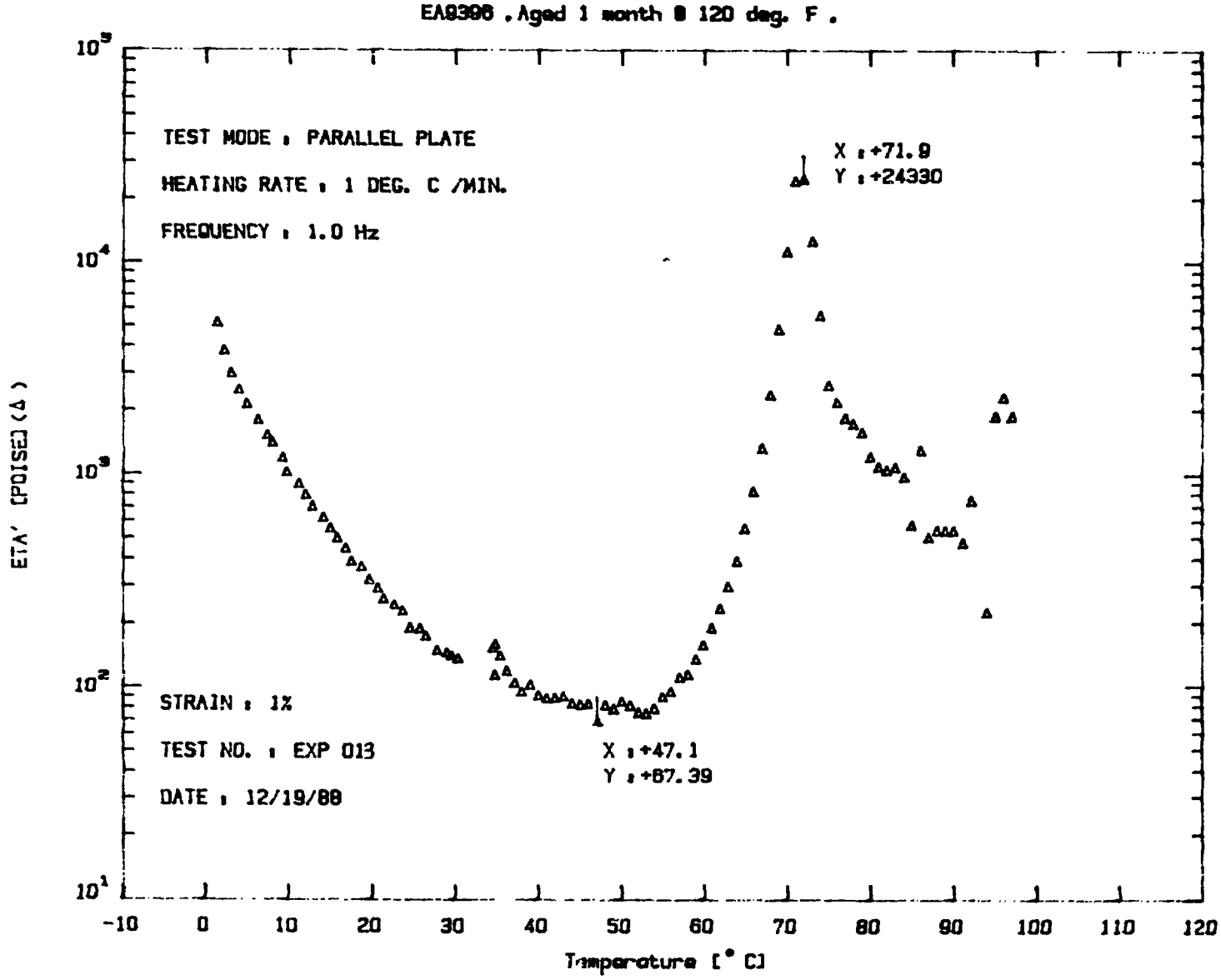


Figure M.57. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 1 Month.

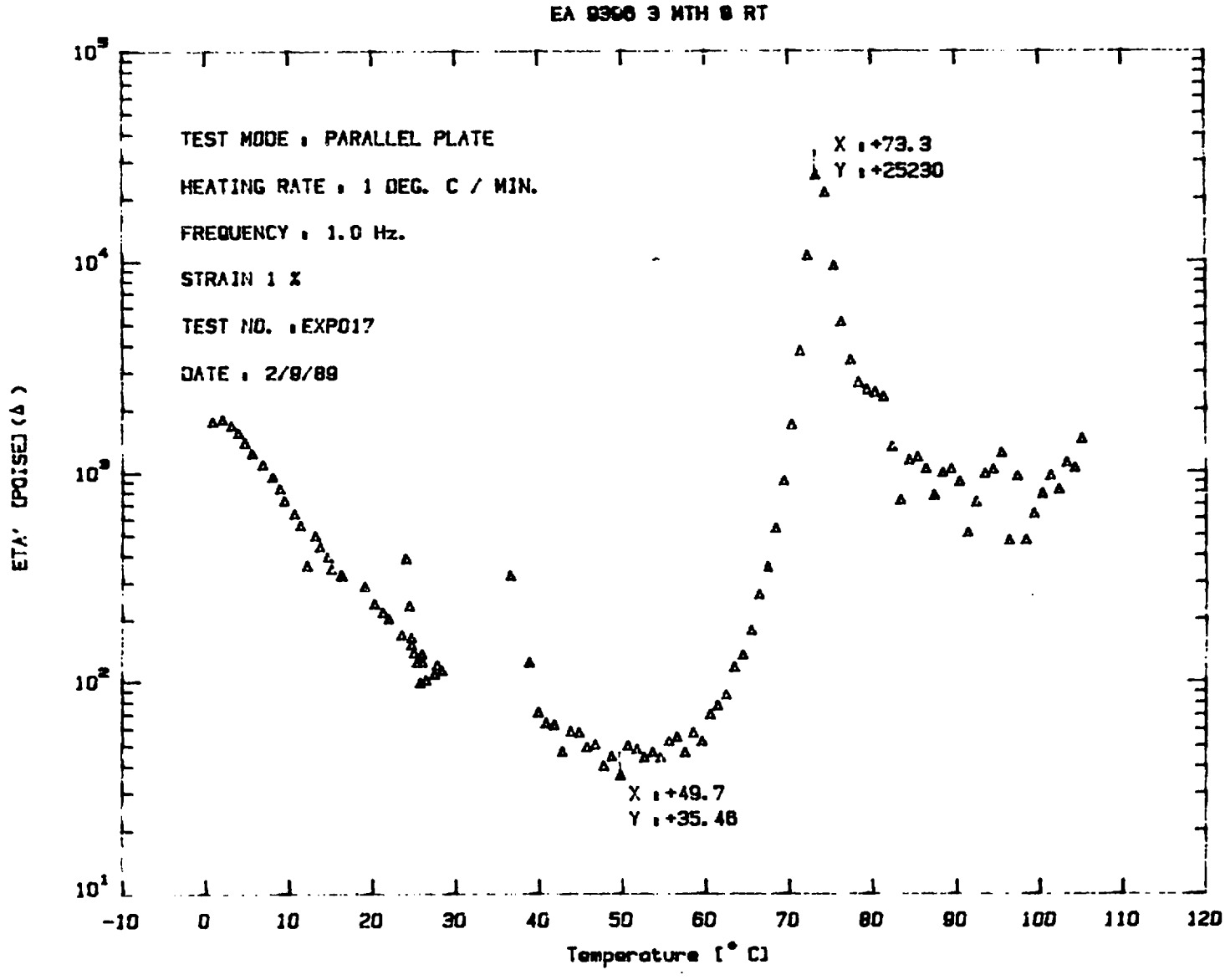


Figure M.58. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 3 Months.

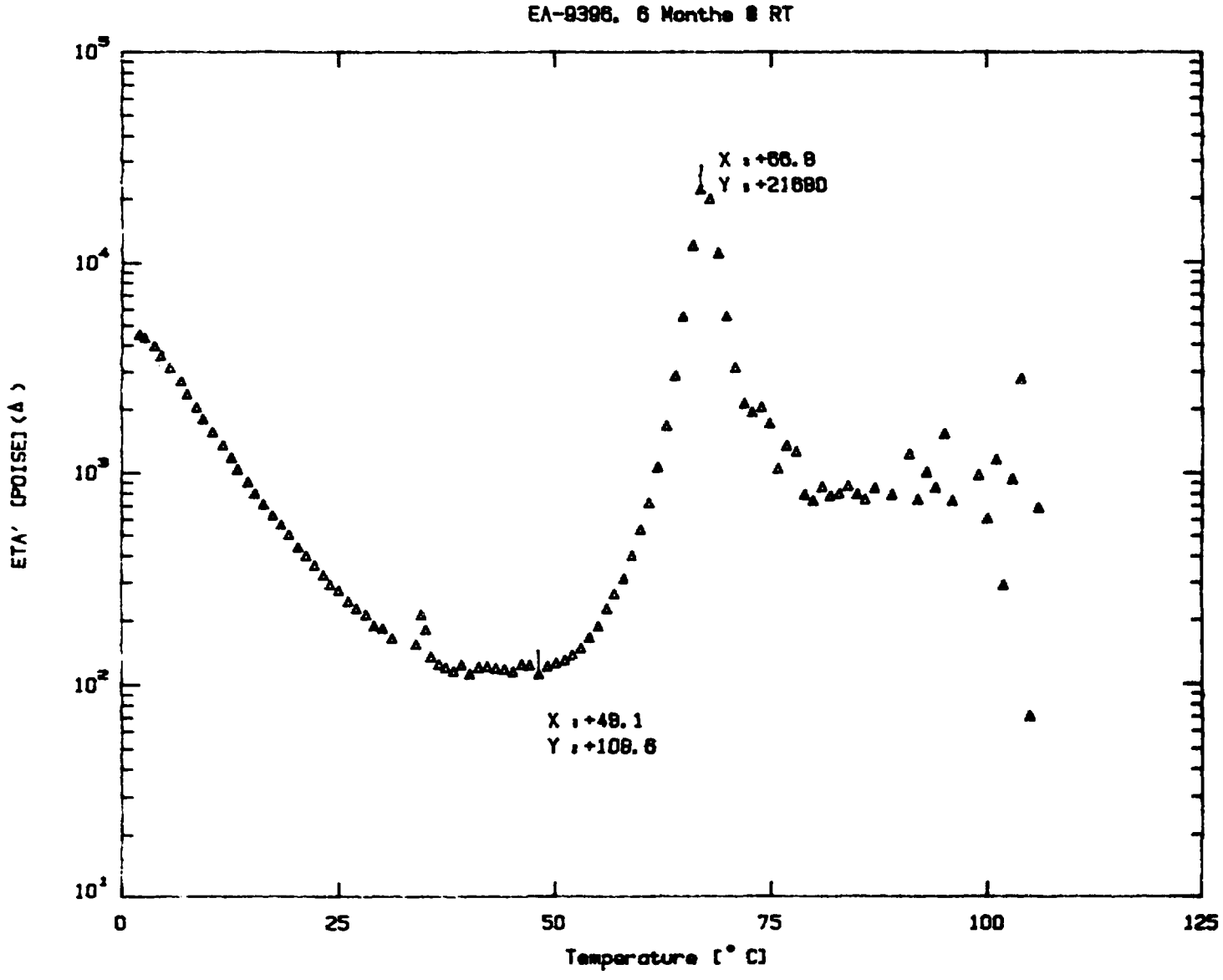


Figure M.59. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 6 Months.

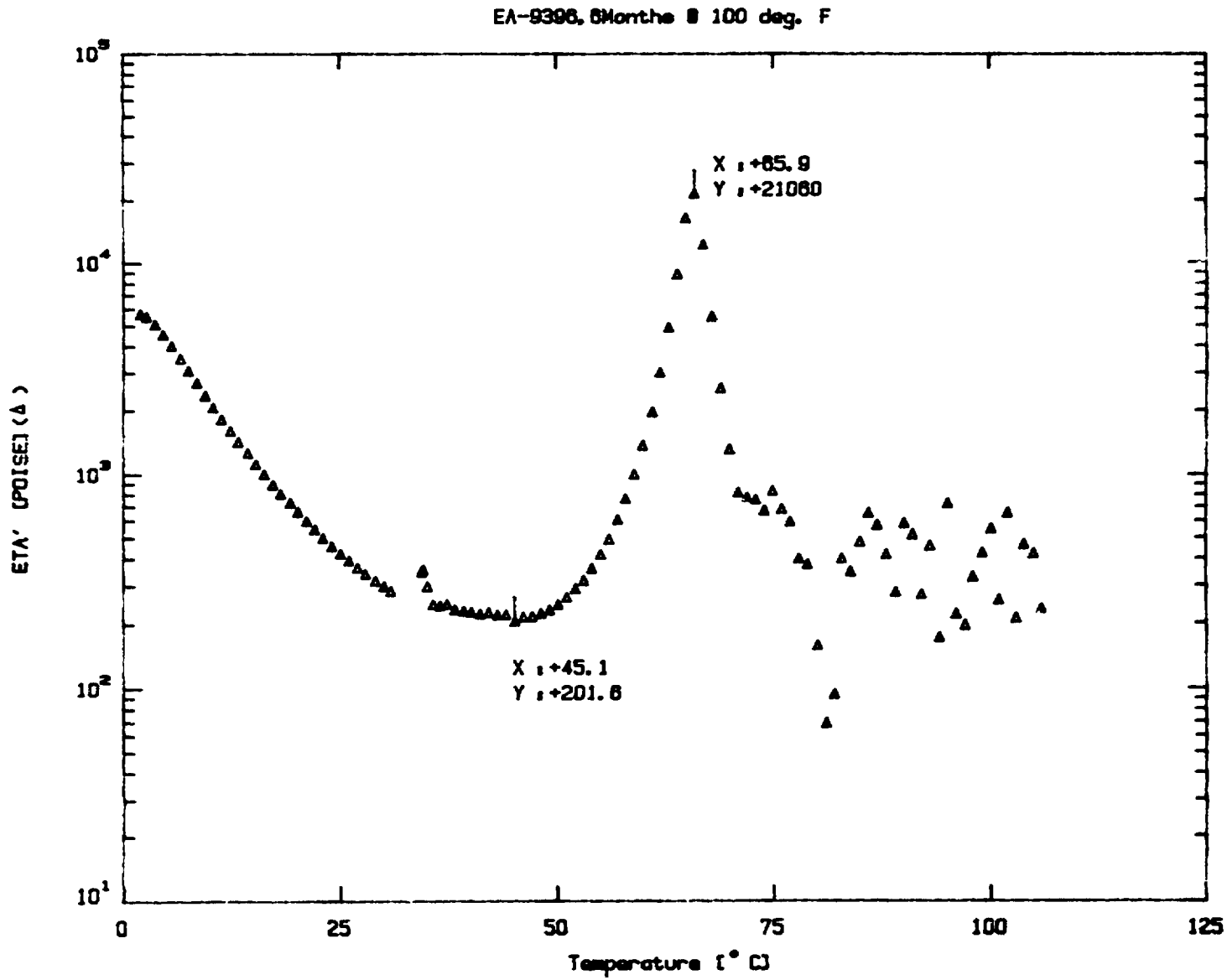


Figure M.60. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 6 Months.

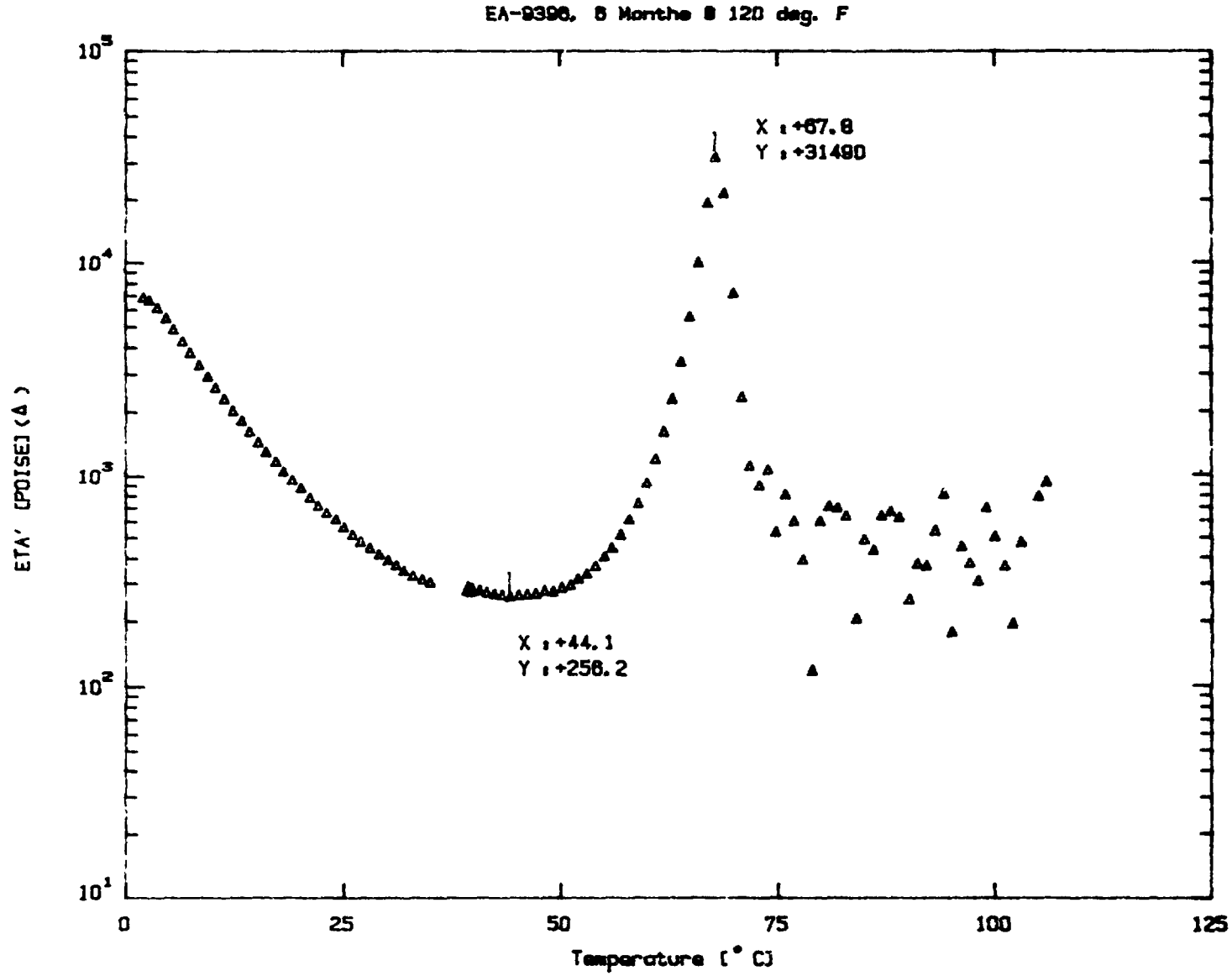


Figure M.61. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 6 Months.

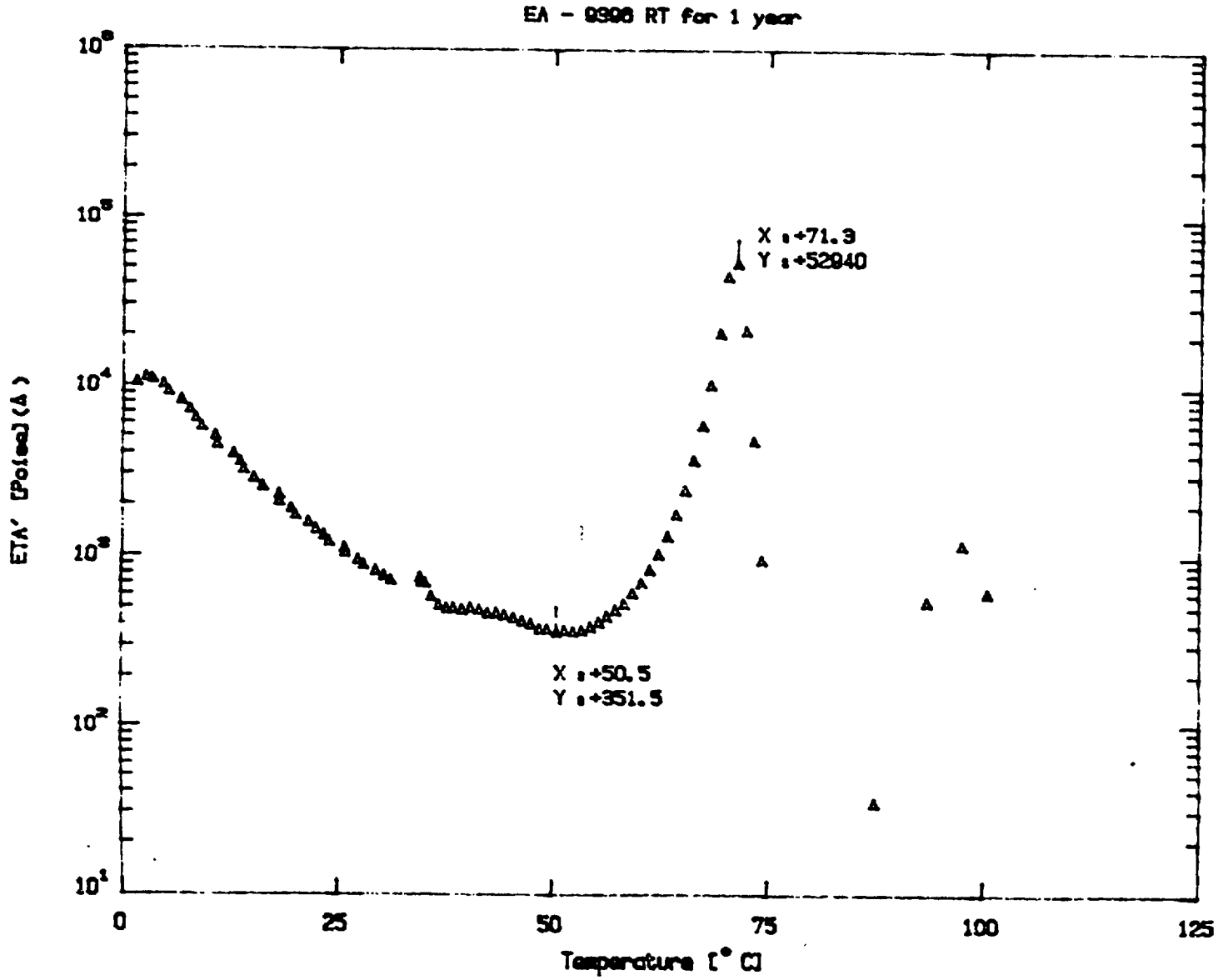


Figure M.62. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 12 Months.

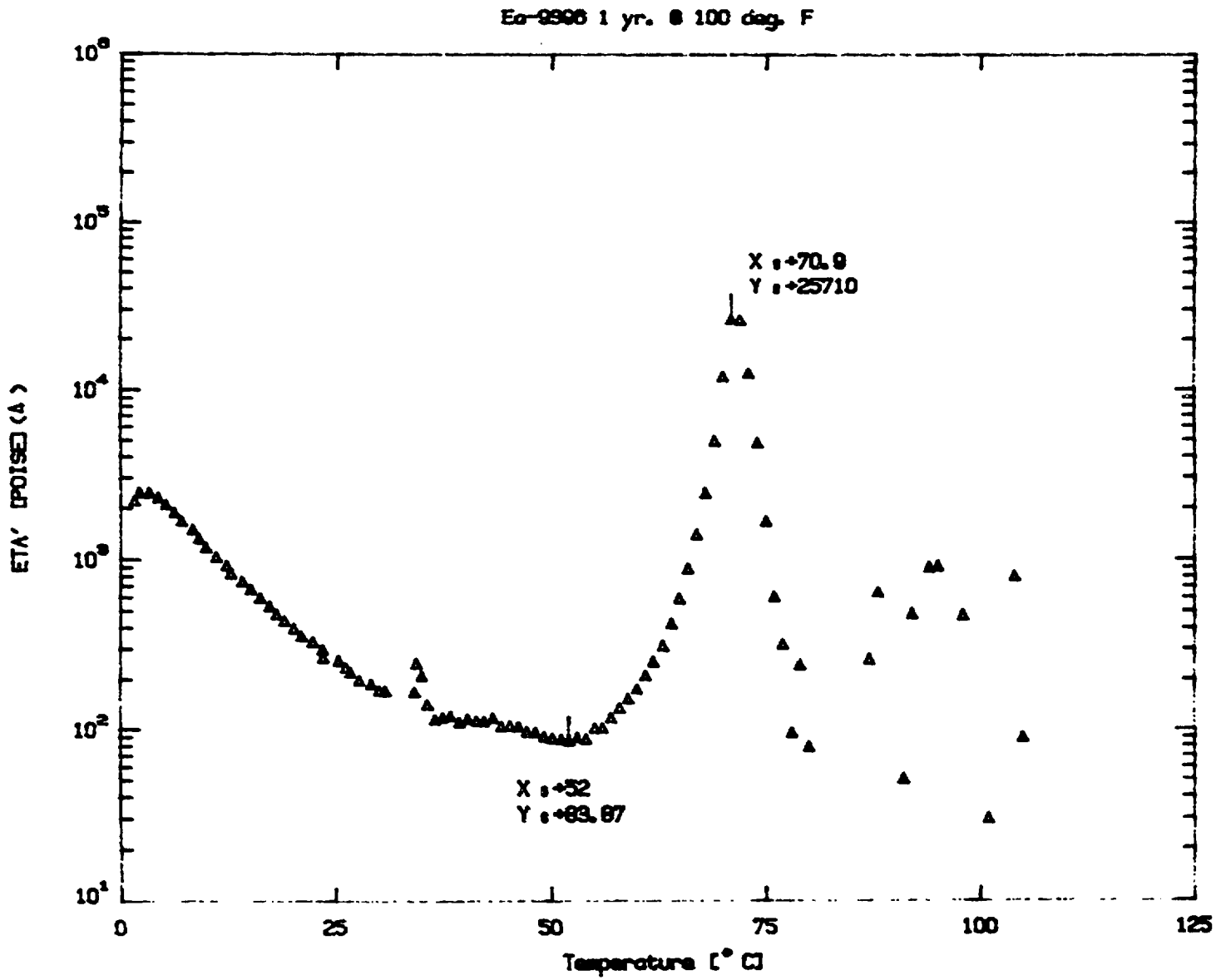


Figure M.63. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 12 Months.

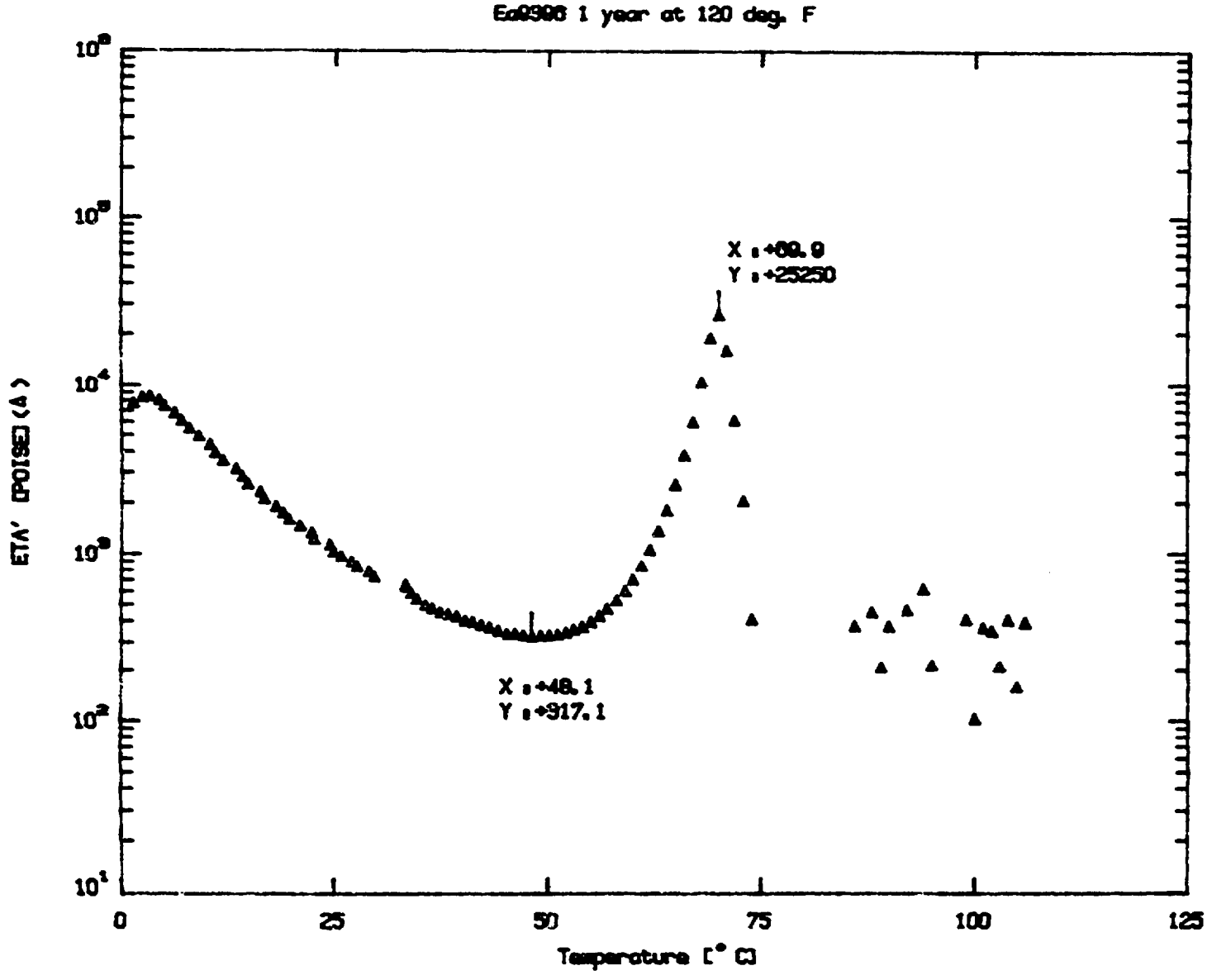


Figure M.64. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 12 Months.

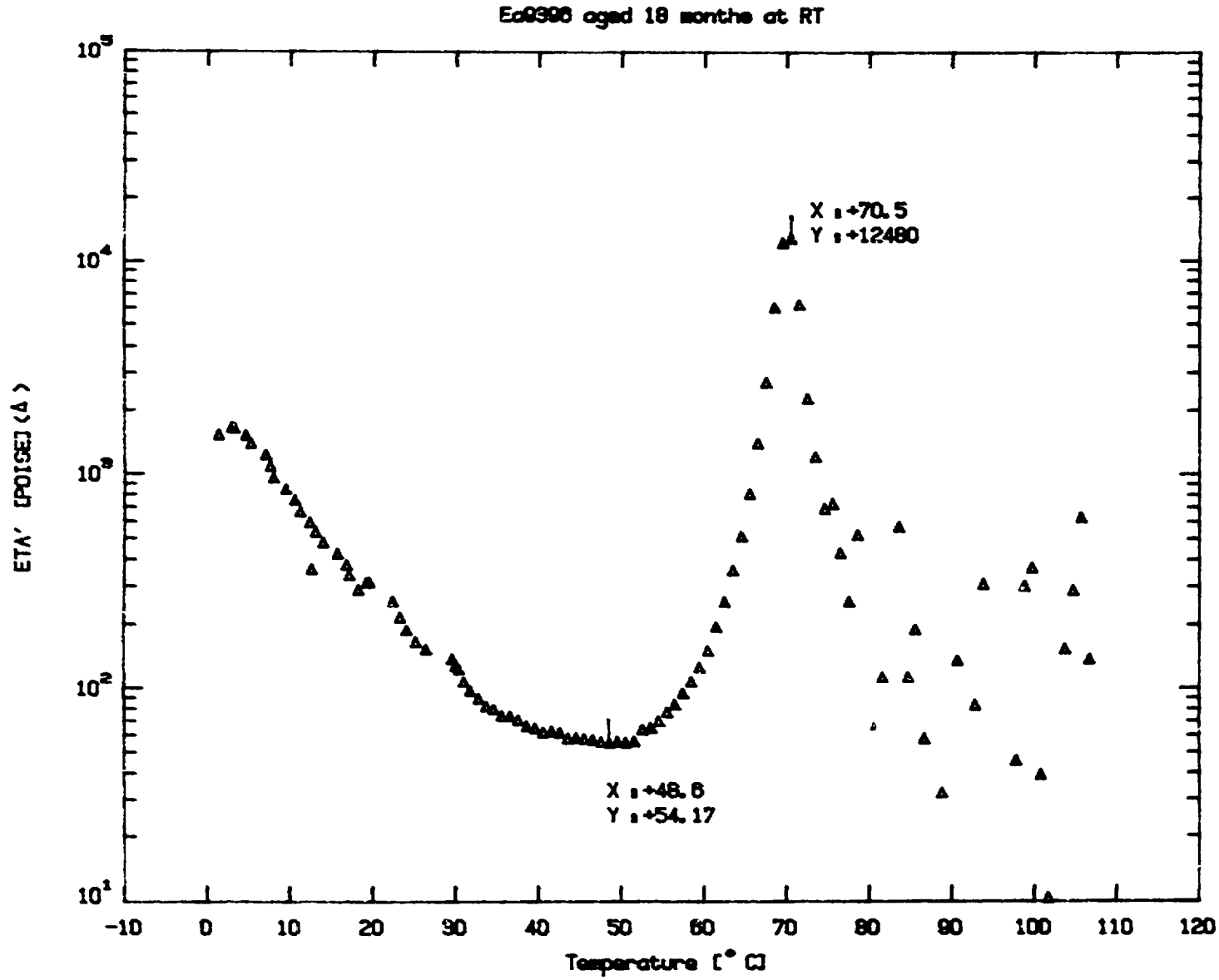


Figure M.65. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 18 Months.

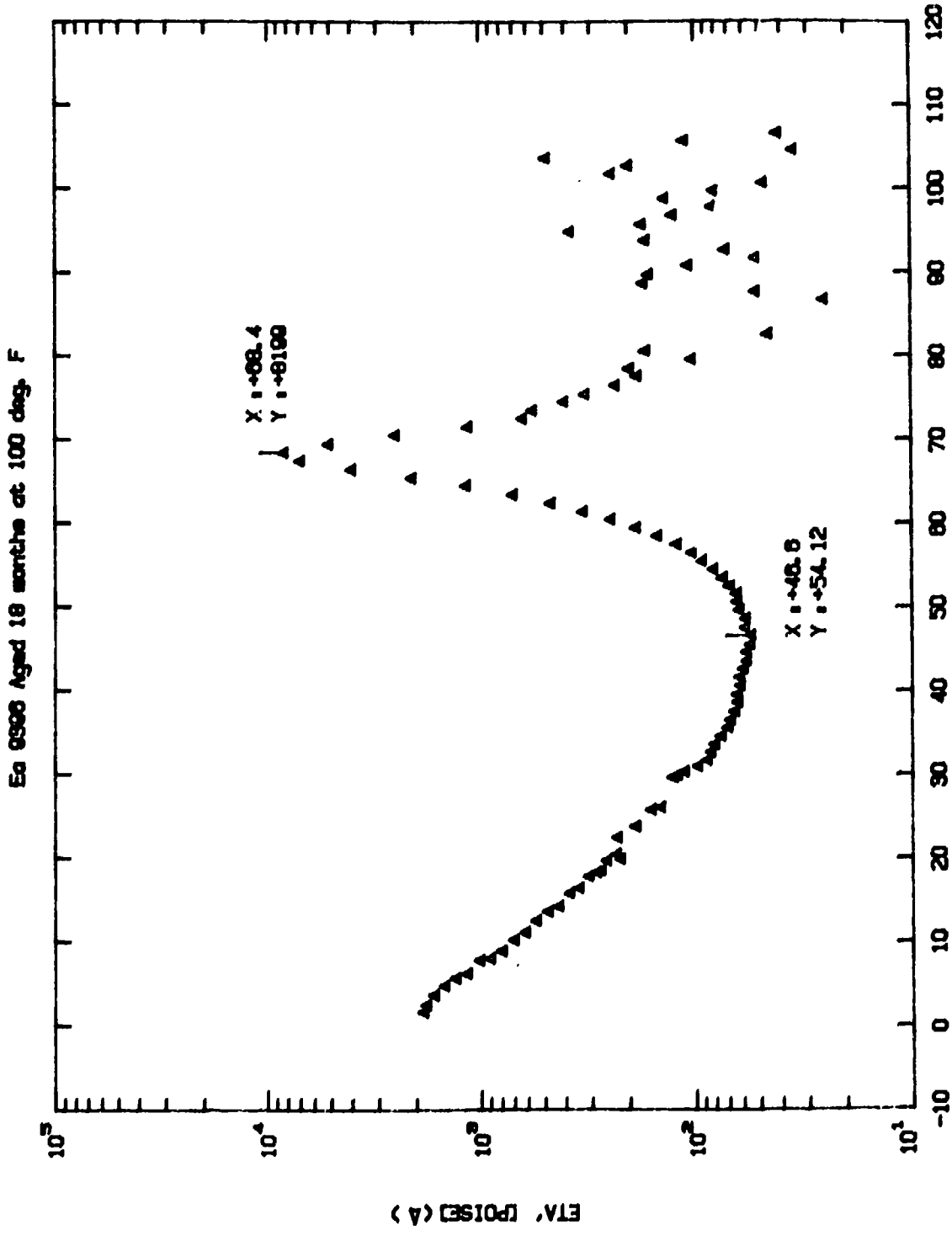


Figure M.66. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 18 Months.

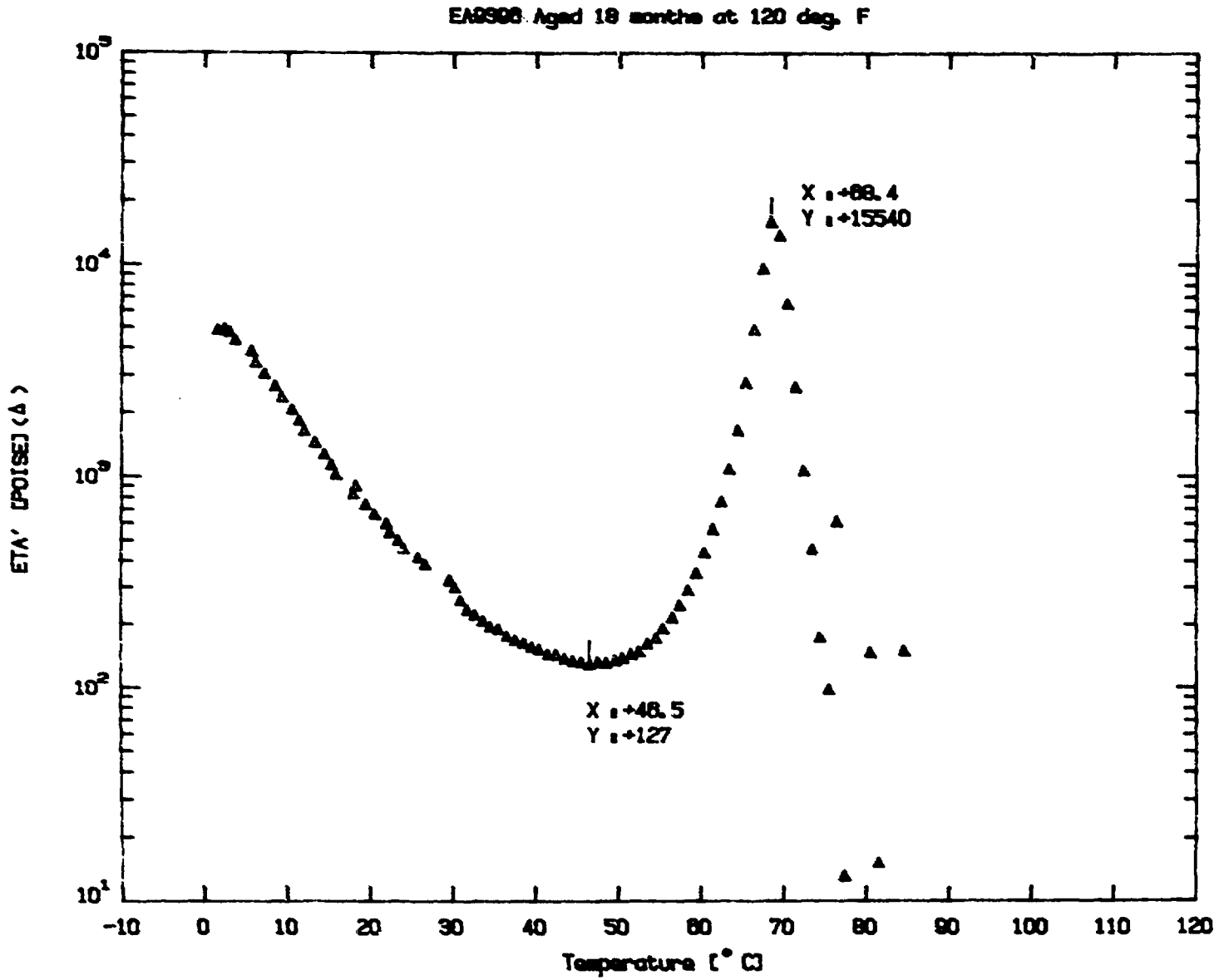


Figure M.67. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 18 Months.

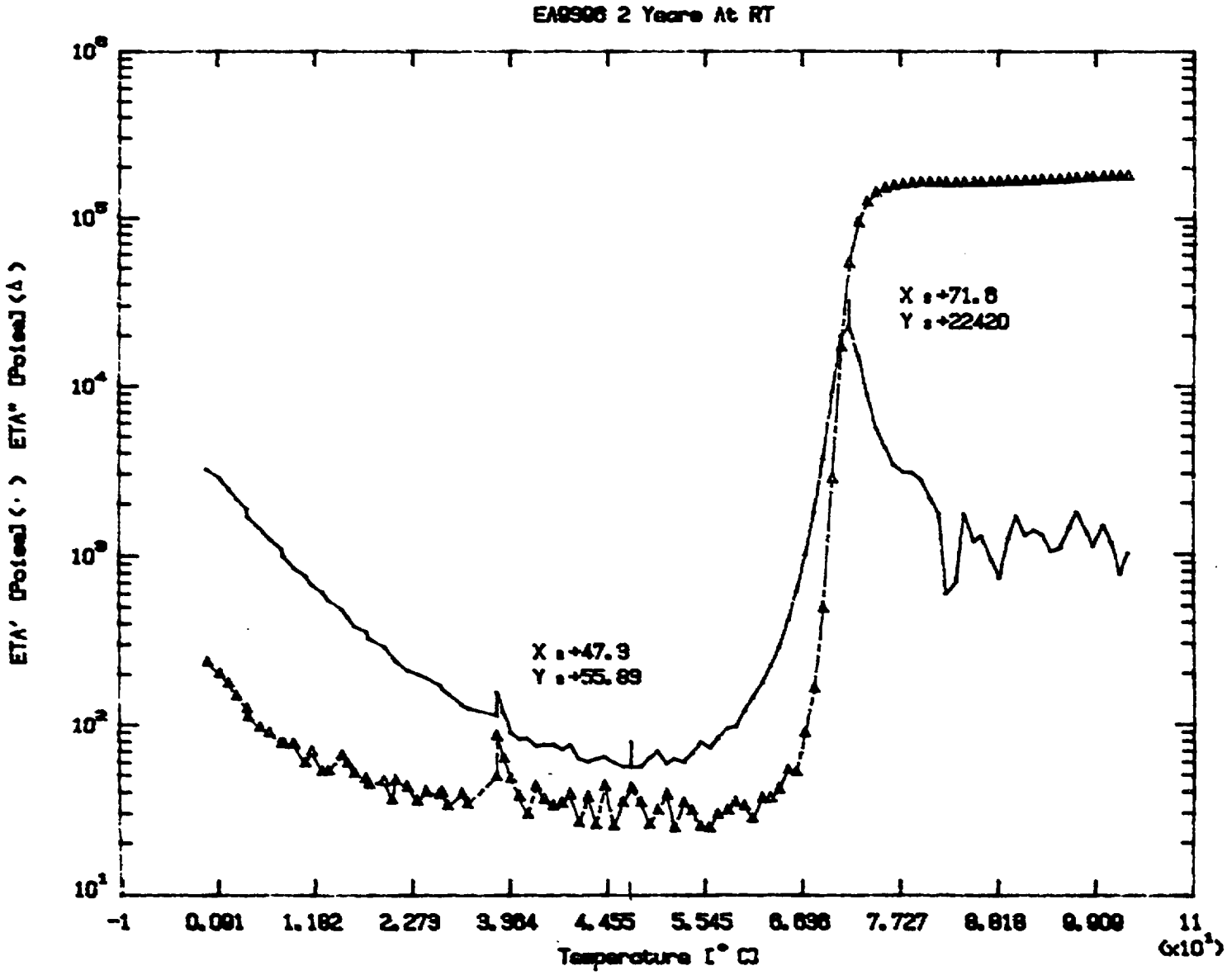


Figure M.68. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 24 Months.

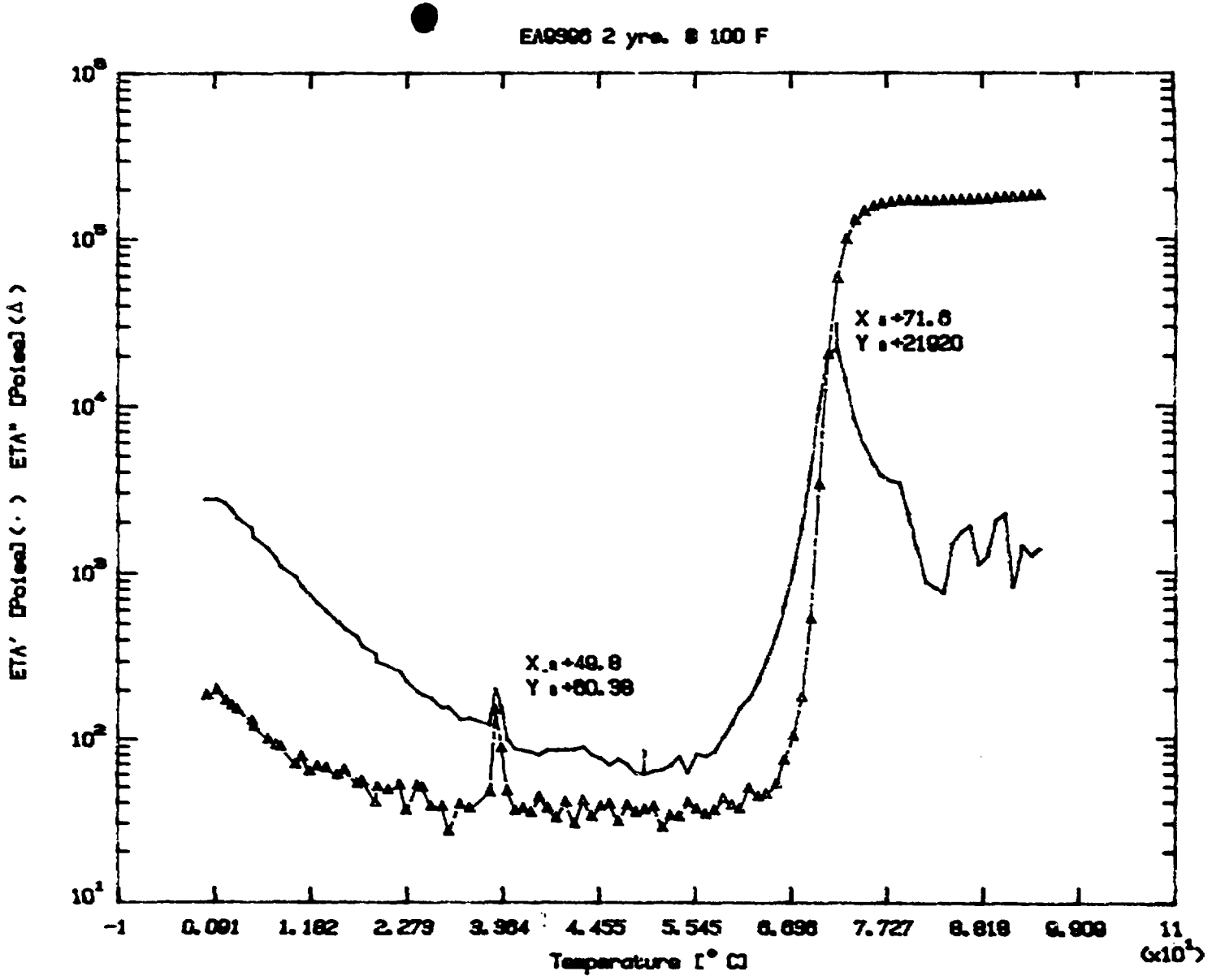


Figure M.69. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 24 Months.

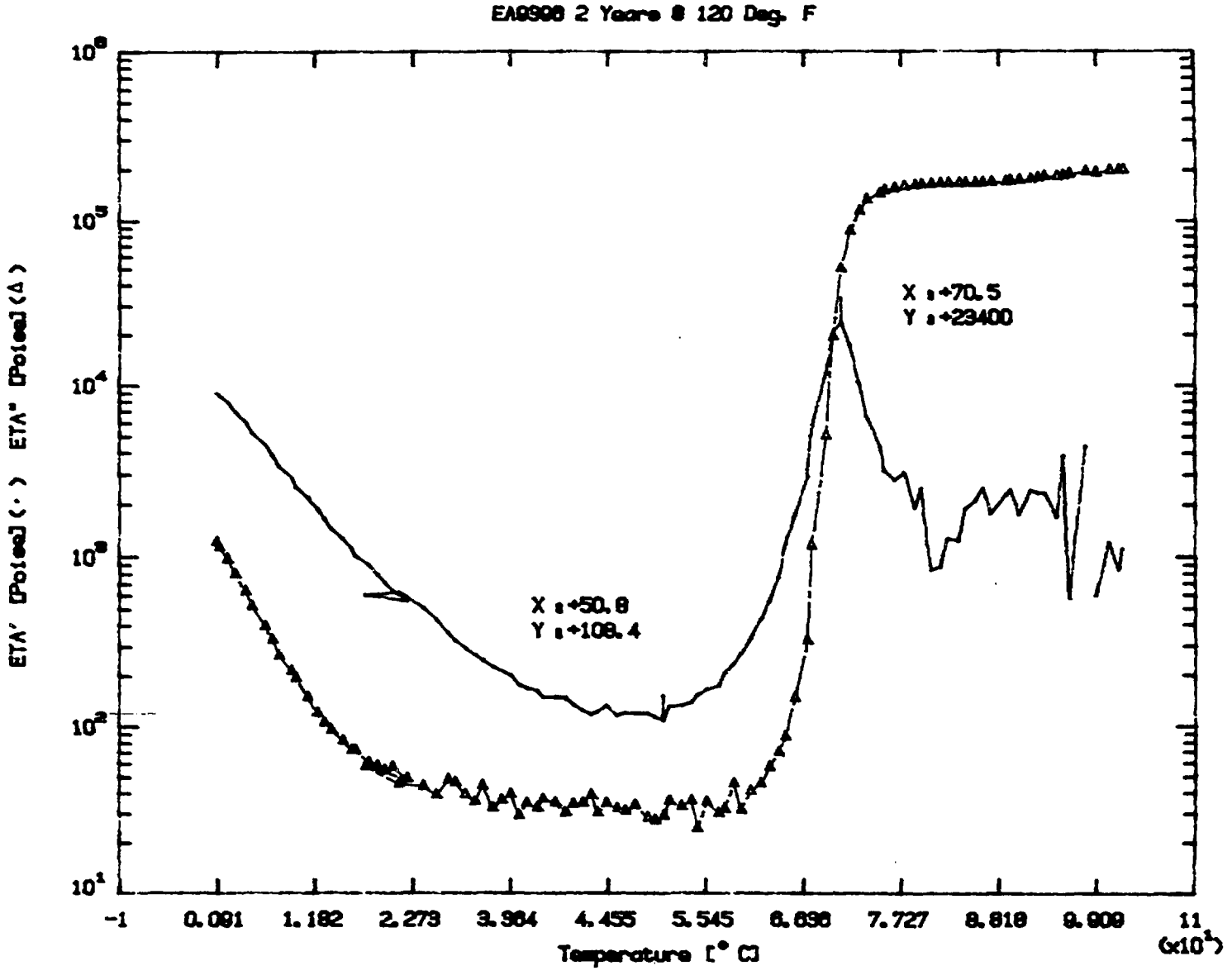


Figure M.70. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 24 Months.

APPENDIX N

INDIVIDUAL SPECIMEN HONEYCOMB FLATWISE TENSILE PROPERTIES, EFFECT OF ADHESIVE FILLET SIZE

When honeycomb sandwich constructions are pulled apart in a flatwise tension mode, the limiting strength is that of the core. Heavier core, with smaller cell size and higher cell wall thickness obviously requires higher loads to tear the core than lighter core. The strength of the core however does not necessarily determine the flatwise tensile strength of a honeycomb construction. Failure may occur at lower loads than that required to fail the core because a variety of other failure modes can occur. Some of these alternative failure modes include debonding of the adhesive from the facing shin, debonding of the adhesive fillets from the core cell walls, cohesive failure within the adhesive itself, or, in the case of composite skins, delamination of the facing skins. Whichever of these various locations is the "weakest-link-in-the-chain" will fail first.

Probably the most common of these alternative failure modes is the failure of the bond between the adhesive fillets and the core cell walls and the leading reason for this is inadequate fillet size. It is intuitively obvious that as the adhesive fillet size increases, and concurrently the area of the fillet-cell wall bond increases, this "link-in-the-chain" will become stronger and failure loads will increase until the strength of the next weakest link in the chain is exceeded.

Since the fillet size is the most easily controlled variable in a honeycomb sandwich bond (one only has to use more adhesive to increase the fillet size), the effect of this variable on flatwise tensile strength was investigated.

Honeycomb sandwich panels were prepared and tested with varying amounts of adhesive (ranging from none to 0.73 gm/cm^2) between the skin and the core. The individual specimen flatwise tensile strengths obtained from these panels are presented in Tables N.1 - N.5. These results were summarized and discussed in Section 3.10.2.

TABLE N.1

FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
WITH NO SUPPLEMENTAL ADHESIVE

Test :	Flatwise tension; ASTM C297-88			Task #9						Tested by:	DRB
Material:	Hysol EA-9396 A/B; W133 Graphite Skins			CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core							
		Specimen Width		Maximum	Flatwise		Failure Mode				
Specimen	Test	1	2	Load	Tensile Strength		A/C	A/S	A	C	Date	
Number	Temperature	(in.)	(in.)	(lbs.)	(Psi.)	(MPa)	(%)	(%)	(%)	(%)	Tested	Remarks
BIL-GR-65-1	22°C (72°F) (DRY)	2.000	2.000	725	181.3	1.250	10	80	10	0	3/29/90	(1,2,3)
BIL-GR-65-2	"	2.000	2.000	625	156.3	1.077	10	80	10	0	"	(1,2,3)
BIL-GR-65-3	"	2.000	2.000	875	218.8	1.508	10	80	10	0	"	(1,2,3)
BIL-GR-65-4		2.000	2.000	1,750	437.5	3.017	10	0	90	0	"	(1,2,3)
				Average	248.4	1.713						
				Std. Dev.	128.6	0.887						

Remarks:

(1) Failure Mode:

A/C: Fillet-to-core interface (bare honeycomb)

A/S: Adhesive-to-skin interface (bare aluminum or composite skin)

A: Cohesive within adhesive (between base of fillet and adhesive layer)

C: Core tearing

(2) Failed on top side of core.

(3) No adhesive present between core and either skin.

TABLE N.2

FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
WITH MODERATE ADHESIVE LAYER ALONG TOP SKIN

Test :	*Flatwise tension; ASTM C297-88*			*Task #9*							Tested by:	DRB
Material:	Hysol EA-9396 A/B; W133 Graphite Skins			CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core								
		Specimen Width		Maximum	Flatwise		Failure Mode					
Specimen	Test	1	2	Load	Tensile Strength		A/C	A/S	A	C	Date	
Number	Temperature	(in.)	(in.)	(lbs.)	(Psi.)	(MPa)	(%)	(%)	(%)	(%)	Tested	Remarks
BIL-GR-64-1	22°C (72°F) (DRY)	2.000	2.000	2,550	637.5	4.396	10	0	90	0	3/29/90	(1,2,3)
BIL-GR-64-2	"	2.000	2.000	2,875	718.8	4.956	5	0	95	0	"	(1,2,3)
BIL-GR-64-3	"	2.000	2.000	2,320	580.0	3.999	5	0	95	0	"	(1,2,3)
BIL-GR-64-4	"	2.000	2.000	1,975	493.8	3.404	10	0	90	0	"	(1,2,3)
			Average		607.5	4.189						
			Std. Dev.		94.8	0.654						

Remarks:

(1) Failure Mode:
- A/C: Fillet-to-core interface (bare honeycomb)
- A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
- A: Cohesive within adhesive (between base of fillet and adhesive layer)
- C: Core tearing

(2) Failed on bottom side of core.

(3) 0.21 gm/cm² adhesive between core and top skin.

TABLE N.3

FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
WITH LIGHT ADHESIVE LAYER ALONG BOTH SKINS

Test :	Flatwise tension; ASTM C297-88			Task #9b						Tested by:		DRB
Material:	Hysol EA-9396 A/B; W133 Graphite Skins			CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core								
		Specimen Width		Maximum	Flatwise		Failure Mode					
Specimen	Test	1	2	Load	Tensile Strength		A/C	A/S	A	C	Date	
Number	Temperature	(in.)	(in.)	(lbs.)	(Psi.)	(MPa)	(%)	(%)	(%)	(%)	Tested	Remarks
BIL-GR-81-1	22°C (72°F) (DRY)	2.000	2.000	2,889	722.3	4.980	20	65	15	0	9/10/90	(1,2)
BIL-GR-81-2	"	2.000	2.000	3,267	816.8	5.631	35	60	5	0	"	(1,2)
BIL-GR-81-3	"	2.000	2.000	2,901	725.3	5.001	50	45	5	0	"	(1,2)
BIL-GR-81-4	"	2.000	2.000	2,959	739.8	5.101	30	70	0	0	"	(1,2)
				Average	751.0	5.178						
				Std. Dev.	44.5	0.307						

Remarks:

(1) Failure Mode:

A/C: Fillet-to-core interface (bare honeycomb)

A/S: Adhesive-to-skin interface (bare aluminum or composite skin)

A: Cohesive within adhesive (between base of fillet and adhesive layer)

C: Core tearing

(2) 0.08 gm/cm² adhesive between core and both skins.

TABLE N.4

FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
WITH MODERATE ADHESIVE LAYER ALONG BOTH SKINS

Test :	Flatwise tension; ASTM C297-88			Task #9b						Tested by:	DRB
Material:	Hysol EA-9396 A/B; W133 Graphite Skins			CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core							
		Specimen Width		Maximum	Flatwise		Failure Mode				
Specimen	Test	1	2	Load	Tensile Strength		A/C	A/S	A	C	Date
Number	Temperature	(in.)	(in.)	(lbs.)	(Psi.)	(MPa)	(%)	(%)	(%)	(%)	Tested	Remarks
BIL-GR-83-1	22°C (72°F) (DRY)	2.000	2.000	3,219	804.8	5.549	0	65	35	0	9/10/90	(1,2)
BIL-GR-83-2	"	2.000	2.000	3,279	819.8	5.652	10	50	40	0	"	(1,2)
BIL-GR-83-3	"	2.000	2.000	3,490	872.5	6.016	20	40	40	0	"	(1,2)
BIL-GR-83-4	"	2.000	2.000	3,552	888.0	6.123	10	45	45	0	"	(1,2)
				Average	846.3	5.835						
				Std. Dev.	40.2	0.277						

Remarks:

(1) Failure Mode:

A/C: Fillet-to-core interface (bare honeycomb)

A/S: Adhesive-to-skin interface (bare aluminum or composite skin)

A: Cohesive within adhesive (between base of fillet and adhesive layer)

C: Core tearing

(2) 0.21 gm/cm^2 adhesive between core and both skins.

TABLE N.5

FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
WITH HEAVY ADHESIVE LAYER ALONG BOTH SKINS

Test :	Flatwise tension; ASTM C297-88			Task #9b						Tested by:		DRB
Material:	Hysol EA-9396 A/B; W133 Graphite Skins			CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core								
		Specimen Width		Maximum	Flatwise		Failure Mode					
Specimen	Test	1	2	Load	Tensile Strength		A/C	A/S	A	C	Date	
Number	Temperature	(in.)	(in.)	(lbs.)	(Psi.)	(MPa)	(%)	(%)	(%)	(%)	Tested	Remarks
BIL-GR-88-1	22°C (72°F) (DRY)	2.000	2.000	3,915	978.8	6.748	55	45	0	0	7/23/91	(1,2,3)
BIL-GR-88-2	"	2.000	2.000	3,725	931.3	6.421	55	45	0	0	"	(1,2,3)
BIL-GR-88-3	"	2.000	2.000	4,120	1030.0	7.102	0	0	0	0	"	(1,2,4)
				Average	980.0	6.757						
				Std. Dev.	49.4	0.341						

Remarks:

(1) Failure Mode:
A/C. Fillet-to-core interface (bare honeycomb)
A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
A: Cohesive within adhesive (between base of fillet and adhesive layer)
C: Core tearing

(2) 0.73 gm/cm² adhesive between core and both skins.

(3) Most of the failure within the adhesive layer consisted of debonding of the adhesive from the glass scrim fabric.

(4) Failure was 75% delamination of facing skin and 25% debonding between facing skin and loading blocks.

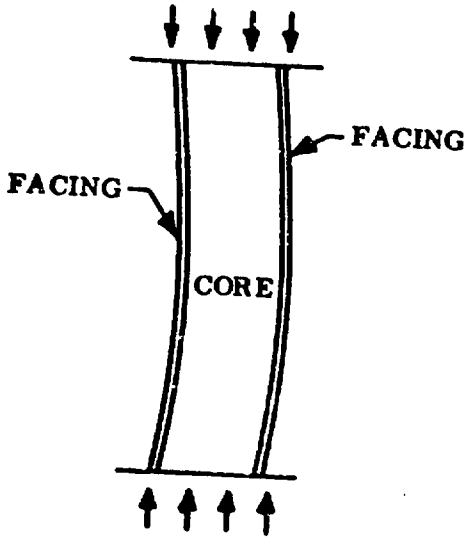
APPENDIX O

INDIVIDUAL SPECIMEN HONEYCOMB SANDWICH EDGEWISE COMPRESSION PROPERTIES, EFFECT OF COCURING VS. SECONDARY BONDING

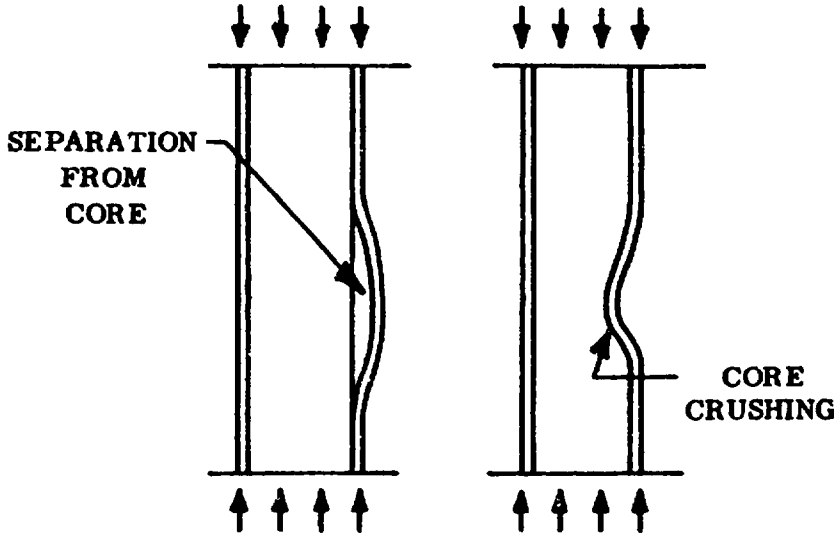
The six tables in this appendix present the detailed edgewise compression strength data for honeycomb sandwich specimens prepared by either cocuring of the skins to the core or secondarily bonding the skins to the core. The specimens consisted of either graphite or glass fabric reinforced skins on two different density aluminum honeycomb cores.

In order to prevent crushing of the ends of the sandwich specimens during loading, approximately 4.5 cm (1.75 in) of the core on each end of the specimen was filled with epoxy resin, leaving a central, unpotted, gage section between the loading fixtures of approximately 14 cm (5.5 in).

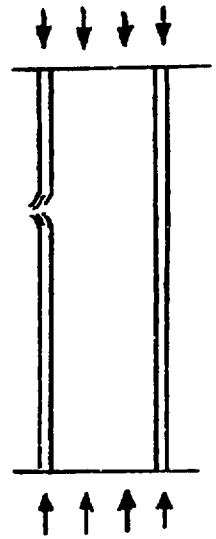
Figure O.1 illustrates the various failure modes observed for these specimens.



A. General Buckling



B. Wrinkling of Facings



C. Skin Compression

Figure 0.1. Types of Failure Modes Observed in Edgewise Compression Tests.

TABLE 0.1

EDGEWISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH LIGHT CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite 2-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation: Fill	Core Orientation: "W"	Bonding Approach: Cocured	

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	(MPa)	Date Tested	Remarks
9A-1-1	22°C (72°F) (DRY)	2.980	0.0710	7,388	34.92	240.8	1/22/90	(1a,1e,2)
9A-1-2	"	2.975	0.0710	10,293	48.73	336.0	1/23/91	(1a,1e,2)
9A-1-3	"	2.970	0.0710	8,628	40.92	282.1	"	(1a,1e,2)
				Average	41.52	286.3		
				Std. Dev.	6.93	47.8		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.2

EDGEWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH
WITH LIGHT CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite 2-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation: Fill	Core Orientation: "W"	Bonding Approach: Secondarily Bonded	

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	(MPa)	Date Tested	Remarks
9A-2-1	22°C (72°F) (DRY)	3.024	0.0670	8,081	39.89	275.0	1/23/91	(1dy,2)
9A-2-2	"	3.088	0.0670	6,021	29.10	200.6	"	(1dy,1e,2)
9A-2-3	"	3.020	0.0670	7,495	37.04	255.4	"	(1dy,2)
				Average	35.34	243.7		
				Std. Dev.	5.59	38.5		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.3

EDGEWISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH HEAVY CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite 2-ply skins	CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation: Fill	Core Orientation: "W"	Bonding Approach: Cocured	

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	Maximum Stress in Facings (MPa)	Date Tested	Remarks
9A-3-1	22°C (72°F) (DRY)	2.983	0.0670	9,536	47.71	329.0	1/23/91	(1dx,1e,2)
9A-3-2	"	2.960	0.0670	9,766	49.24	339.5	1/24/91	(1dx,1e,2)
9A-3-3	"	2.964	0.0670	8,892	44.77	308.7	"	(1dx,1e,2)
				Average	47.24	325.7		
				Std. Dev.	2.27	15.7		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.4

EDGEWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH WITH HEAVY CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364		Task #9A		Tested By: PM		
Material :	EA-9396 A/B; W133 Graphite	2-ply skins	CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core				
Reinforcement Orientation:	Fill	Core Orientation:	"L"		Bonding Approach:		Secondarily Bonded

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	Maximum Stress in Facings (MPa)	Date Tested	Remarks
9A-4-2	22°C (72°F) (DRY)	2.975	0.0650	7,647	39.54	272.6	1/24/91	(1dy,1e,2)
9A-4-3	"	2.962	0.0650	7,524	39.08	269.5	"	(1dy,2)
				Average	39.31	271.1		
				Std. Dev.	0.33	2.2		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.5

EDGEWISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH LIGHT CORE AND GLASS REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; 7781 Glass 4-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation: Fill	Core Orientation: "W"	Bonding Approach: Cocured	

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	(MPa)	Date Tested	Remarks
9A-5-1	22°C (72°F) (DRY)	2.955	0.0860	11,271	44.35	305.8	1/24/91	(1a,dx,e,2)
9A-5-2	"	2.970	0.0860	10,625	41.60	286.8	"	(1a,dx,e,2)
9A-5-3	"	2.965	0.0860	10,654	41.78	288.1	"	(1a,dx,e,2)
				Average	42.58	293.6		
				Std. Dev.	1.54	10.6		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkiing of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.6

EDGEWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH WITH LIGHT CORE AND GLASS REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364		Task #9A			Tested By: PM	
Material :	EA-9396 A/B; 7781 Glass 4-ply skins		CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core				
Reinforcement Orientation: Fill		Core Orientation: "L"				Bonding Approach: Secondarily Bonded	
Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	(MPa)	Date Tested	Remarks
9A-6-1	22°C (72°F) (DRY)	3.025	0.0800	8,408	34.74	239.6	1/24/91	(1a,dy,2)
9A-6-2	"	2.915	0.0800	6,660	28.56	196.9	1/25/91	(1a,dx,dy,e,2)
9A-6-3	"	3.010	0.0800	11,191	46.47	320.4	"	(1a,dx,e,2)
				Average	36.59	252.3		
				Std. Dev.	9.10	62.7		

Remarks:

(1) Failure Mode:
- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
  - x) Core crushing.
  - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

APPENDIX P
INDIVIDUAL SPECIMEN COMPRESSION PROPERTIES, EFFECT OF THERMAL PULSE

The 13 tables in this appendix present the detailed compression strength data for specimens exposed to a thermal pulse. A summary of these data was presented and discussed in Section 3.12.2.

TABLE P.1

ROOM TEMPERATURE DRY COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
NOT SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781-E Glass			Batch #1	Task #15		Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-25-27	None	22°C (72°F) (DRY)	0.990	0.1405	5,800	41.71	287.6	10/17/90	(1,3,4)
BIL-GL-25-29	"	"	0.999	0.1416	6,140	43.42	299.4	"	(1,3,4)
					Average	42.56	293.5		
					Std. Dev.	1.21	8.4		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.

TABLE P.2

ROOM TEMPERATURE DRY COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781-E Glass		Batch #1		Task #15		Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GL-25-1	Thermal	22°C (72°F) (DRY)	1.040	0.1366	5,670	39.90	275.1	10/17/90	(1,3,4)
BIL-GL-25-3	Pulsed	"	1.039	0.1422	5,940	40.22	277.3	"	(1,3,4)
BIL-GL-25-15	"	"	1.042	0.1414	5,610	38.08	262.6	"	(1,3,4)
BIL-GL-25-12	"	"	1.042	0.1413	6,160	41.85	288.6	"	(1,3,4)
BIL-GL-25-24	"	"	1.042	0.1451	6,850	45.29	312.3	"	(1,3,4)
					Average	41.07	283.2		
					Std. Dev.	2.71	18.7		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)

(2) Specimen failed outside gage section.

(3) Test speed = 0.05 in/min.

(4) Load only recorded.

TABLE P.3

ELEVATED TEMPERATURE DRY COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781-E Glass		Batch #1	Task #15			Tested By:	PM

Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-25-2	Thermal pulsed	93°C (200°F) (DRY)	1.003	0.1409	3,540	25.06	172.8	11/29/90	(1,3,4,5)
BIL-GL-25-4	"	"	1.003	0.1422	3,750	26.30	181.3	"	(1,3,4,5)
BIL-GL-25-11	"	"	1.002	0.1394	3,440	24.63	169.8	"	(1,3,4,5)
BIL-GL-25-13	"	"	1.003	0.1443	4,025	27.82	191.8	"	(1,3,4,5)
BIL-GL-25-15	"	"	1.003	0.1449	3,620	24.91	171.7	"	(1,3,4,5)
					Average	25.74	177.5		
					Std. Dev.	1.33	9.1		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) 15 min. soak at test temperature.

TABLE P.4

LOW TEMPERATURE WET COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781-E Glass		Batch #1	Task #15			Tested By:		PM
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-25-7	Wet aged then	-54°C (-65°F) (WET)	0.999	0.1467	5,640	38.49	265.4	11/27/90	(1,3,4,5,6,7)
BIL-GL-25-9	thermal pulsed	"	1.000	0.1464	6,630	45.31	312.4	"	(1,3,4,5,6,7)
BIL-GL-25-17	"	"	1.005	0.1463	6,120	41.64	287.1	"	(1,3,4,5,6,7)
BIL-GL-25-19	"	"	1.004	0.1432	5,780	40.19	277.1	"	(1,3,4,5,6,7)
BIL-GL-25-22	"	"	1.002	0.1468	5,530	37.60	259.2	"	(1,3,4,5,6,7)
					Average	40.64	280.2		
					Std. Dev.	3.04	20.9		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
(6) Average Weight Gain before thermal pulse = 2.52%
(7) 15 min. soak at test temperature.

TABLE P.5

ROOM TEMPERATURE WET COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
NOT SUBJECTED TO A THERMAL PULSE

Test	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material	EA-9396 A/B; 7781-E Glass			Batch #1	Task #15		Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-25-26	Wet aged: no	22°C (72°F) (WET)	0.988	0.1423	3,200	22.76	157.0	11/20/90	(1,3,4,5,6)
BIL-GL-25-28	thermal pulse	"	0.994	0.1470	3,560	24.37	168.0	"	(1,3,4,5,6)
BIL-GL-25-30	"	"	0.981	0.1400	3,040	22.14	152.7	"	(1,3,4,5,6)
					Average	23.09	159.2		
					Std. Dev.	1.15	7.9		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95-100% R.H. until saturated.
(6) Average Weight Gain = 1.85%

TABLE P.6

ROOM TEMPERATURE WET COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; 7781-E Glass		Batch #1	Task #15			Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-25-6	Wet aged then	22°C (72°F) (WET)	0.999	0.1476	3,420	23.21	160.0	11/20/90	(1,3,4,5,6)
BIL-GL-25-10	thermal pulsed	"	0.998	0.1446	3,550	24.60	169.6	"	(1,3,4,5,6)
BIL-GL-25-18	"	"	1.004	0.1446	3,235	22.27	153.6	"	(1,3,4,5,6)
BIL-GL-25-21	"	"	1.002	0.1461	2,845	19.43	134.0	"	(1,3,4,5,6)
BIL-GL-25-24	"	"	1.002	0.1454	2,470	16.95	116.9	"	(1,3,4,5,6)
					Average	21.29	146.8		
					Std. Dev.	3.08	21.2		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
(6) Average Weight Gain before thermal pulse = 2.52%

TABLE P.7

ELEVATED TEMPERATURE WET COMPRESSION STRENGTH
OF GLASS REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; 7781-E Glass		Batch #1	Task #15			Tested By:	PM

Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GL-25-8	Wet aged then	93°C (200°F) (WET)	0.998	0.1443	1,430	9.93	68.5	11/26/90	(1,3,4,5,6,7)
BIL-GL-25-16	thermal pulsed	"	1.004	0.1455	1,565	10.71	73.9	"	(1,3,4,5,6,7)
BIL-GL-25-20	"	"	1.003	0.1388	1,485	10.66	73.5	"	(1,3,4,5,6,7)
BIL-GL-25-23	"	"	1.002	0.1438	1,420	9.86	68.0	"	(1,3,4,5,6,7)
BIL-GL-25-25	"	"	1.001	0.1429	1,440	10.06	69.4	"	(1,3,4,5,6,7)
					Average	10.25	70.6		
					Std. Dev.	0.41	2.8		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
(6) Average Weight Gain before thermal pulse = 2.52%
(7) 4 min. soak after test oven door closed.

TABLE P.8

ROOM TEMPERATURE DRY COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
NOT SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410							Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #15			Tested By:	DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-50-27	None	22°C (72°F) (DRY)	0.996	0.1892	11,270	59.82	412.5	10/17/90	(1a,3,4)
BIL-GR-50-29	"	"	1.001	0.1942	13,630	70.14	483.6	"	(1a,3,4)
					Average	64.98	448.0		
					Std. Dev.	7.29	50.3		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
   a) Shear crimping
   b) Shear fracture

(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.

TABLE P.9

ROOM TEMPERATURE DRY COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B: W133 Graphite		Batch #1	Task #15			Tested By:	DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-1	Thermal pulsed	22°C (72°F) (DRY)	1.040	0.1901	12,970	65.58	452.2	10/17/90	(1a,3,4)
BIL-GR-50-3	"	"	1.040	0.1905	10,300	52.00	358.6	"	(1b,3,4)
BIL-GR-50-5	"	"	1.043	0.1956	12,380	60.69	418.5	"	(1a,3,4)
BIL-GR-50-12	"	"	1.043	0.1970	10,240	49.83	343.6	"	(1b,3,4)
BIL-GR-50-14	"	"	1.040	0.1897	11,550	58.56	403.7	"	(1a,3,4)
					Average	57.33	395.3		
					Std. Dev.	6.43	44.4		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
   a) Shear crimping
   b) Shear fracture

(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.

TABLE P.10

ELEVATED TEMPERATURE DRY COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410							Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1		Task #15			Tested By:	PM
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-50-2	Thermal pulsed	93°C (200°F) (DRY)	0.979	0.1891	8,157	44.06	303.8	4/17/91	(1,3,4)
BIL-GR-50-4	"	"	1.001	0.1919	7,905	41.17	283.9	"	(1,3,4)
BIL-GR-50-11	"	"	0.988	0.1947	7,949	41.32	284.9	"	(1,3,4)
BIL-GR-50-13	"	"	0.988	0.1960	8,406	43.40	299.2	"	(1,3,4)
BIL-GR-50-15	"	"	0.985	0.1788	8,047	45.68	315.0	"	(1,3,4)
					Average	43.12	297.3		
					Std. Dev.	1.91	13.2		

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear crimping)

(2) Specimen failed outside gage section.

(3) Test speed = 0.05 in/min.

(4) 15 min. soak at test temperature.

TABLE P.11

LOW TEMPERATURE WET COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:		Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1		Task #15		Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GR-50-7	Wet aged then	-54°C (-65°F) (WET)	0.995	0.2068	13,760	66.85	460.9	11/28/90	(1a,3,4,5,6,7)
BIL-GR-50-9	thermal pulsed	"	0.998	0.2050	15,660	76.54	527.7	"	(1a,3,4,5,6,7)
BIL-GR-50-17	"	"	1.006	0.2061	13,800	66.55	458.9	"	(1a,3,4,5,6,7)
BIL-GR-50-19	"	"	1.007	0.1913	14,340	74.43	513.2	"	(1a,3,4,5,6,7)
BIL-GR-50-22	"	"	1.000	0.1975	14,800	74.94	516.7	"	(1a,3,4,5,6,7)
					Average	71.86	495.5		
					Std. Dev.	4.78	32.9		

Remarks.

(1) Specimen failed within the 1/2 inch gage section.
   a) Shear crimping
   b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
(6) Average Weight Gain before thermal pulse = 1.90%
(7) 15 min. soak at test temperature.

TABLE P.12

ROOM TEMPERATURE WET COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
NOT SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410						Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite		Batch #1	Task #15			Tested By:	DRB

Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-26	Wet aged; no	22°C (72°F) (WET)	0.998	0.1983	8,900	44.97	310.0	11/20/90	(1a,3,4,5,6)
BIL-GR-50-28	thermal pulse	"	0.991	0.1977	9,080	46.33	319.5	"	(1b,3,4,5,6)
BIL-GR-50-30	"	"	0.995	0.1874	8,500	45.59	314.4	"	(1a,3,4,5,6)
					Average	45.63	314.6		
					Std. Dev.	0.68	4.7		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
   a) Shear crimping
   b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Specimens aged @ 140°F/95–100% R.H. until saturated.
(6) Average Weight Gain = 2.14%

TABLE P.13

ROOM TEMPERATURE WET COMPRESSION STRENGTH
OF GRAPHITE REINFORCED SPECIMENS THAT WERE
SUBJECTED TO A THERMAL PULSE

Test :	IITRI Compression; ASTM-D3410							Fiber Orientation:	Fill
Material :	EA-9396 A/B; W133 Graphite			Batch #1	Task #15			Tested By:	DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-6	Wet aged then	22°C (72°F) (WET)	0.996	0.2050	8,750	42.85	295.5	11/20/90	(1b,3,4,5,6)
BIL-GR-50-10	thermal pulsed	"	0.998	0.2034	8,570	42.24	291.2	"	(1b,3,4,5,6)
BIL-GR-50-18	"	"	1.005	0.1969	9,510	48.04	331.2	"	(1b,3,4,5,6)
BIL-GR-50-21	"	"	0.999	0.1980	9,080	45.93	316.7	"	(1a,3,4,5,6)
BIL-GR-50-24	"	"	0.999	0.1984	9,790	49.42	340.7	"	(1b,3,4,5,6)
					Average	45.69	315.1		
					Std. Dev.	3.14	21.7		

Remarks:

(1) Specimen failed within the 1/2 inch gage section.
   a) Shear crimping
   b) Shear fracture
(2) Specimen failed outside gage section.
(3) Test speed = 0.05 in/min.
(4) Load only recorded.
(5) Speciens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
(6) Average Weight Gain before thermal pulse = 1.90%

APPENDIX Q

INDIVIDUAL SPECIMEN MECHANICAL PROPERTIES, EFFECT OF SILANE SIZING ON ENVIRONMENTAL DEGRADATION OF GLASS REINFORCED LAMINATES

The nine tables in this appendix present the detailed mechanical property data for specimens prepared with silane-sized glass reinforcement. The properties measured on these laminates included tensile, inplane shear, and interlaminar shear. It will be noted in Tables Q.1 - Q.3 that the tensile specimens failed inside the tab area. Figure Q.1 illustrates the location and nature of these failures. A summary of these data was presented and discussed in Section 3.11.

TABLE Q.1

ROOM TEMPERATURE DRY TENSILE PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)			Batch #3	Task #19				Tested by :	DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-44-1	22°C (72°F) (DRY)	0.998	0.0641	2,773	43.38	3.842	12,627	0.103	2/5/90	(2,3,4)
BIL-GL-44-4	"	0 995	0.0731	2,916	40.11	3.483	12,048		"	(2,3,5)
BIL-GL-44-7	"	0.995	0.0722	3,152	43.87	3.435	10,122		"	(2,3,5)
BIL-GL-44-10	"	0.997	0.0738	2,557	34.75	3.503	11,001		"	(2,3,5)
BIL-GL-44-13	"	0.998	0.0729	3,032	41.67	3.460	13,579	0.106	"	(2,3,4)
			Average		40.76	3.545	11,876	0.104		
			Std. Dev.		3.67	0.168	1,354	0.002		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.

SI Conversion		
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
299.1	26.49	12,627
276.6	24.01	12,048
302.5	23.69	10,122
239.6	24.16	11,001
287.3	23.86	13,579
281.0	24.44	11,876
25.3	1.16	1,354

Average
Std. Dev.

TABLE Q.2

ROOM TEMPERATURE WET TENSILE PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)			Batch #3	Task #19				Tested by :	DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-44-2	22°C (72°F) (WET)	0.994	0.0660	2,506	38.19	3.244	12,432		3/19/90	(2,3,5,6,7)
BIL-GL-44-5	"	0.997	0.0728	2,457	33.86	3.068	11,758	0.087	"	(2,3,4,6,7)
BIL-GL-44-8	"	0.997	0.0747	2,675	35.91	3.099	12,466		"	(2,3,5,6,7)
BIL-GL-44-11	"	0.997	0.0726	2,562	35.38	3.093	12,075	0.072	"	(2,3,4,6,7)
BIL-GL-44-14	"	0.997	0.0703	2,494	35.57	3.207	11,904		"	(2,3,5,6,7)
			Average		35.78	3.142	12,127	0.079		
			Std. Dev.		1.56	0.078	315	0.011		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H. for 43 days.
(7) Average Weight Gain = 3.0870%

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	263.3	22.37	12,432
	233.5	21.16	11,758
	247.6	21.37	12,466
	244.0	21.33	12,075
	245.3	22.11	11,904
Average	246.7	21.67	12,127
Std. Dev.	10.7	0.54	315

TABLE Q.3

ELEVATED TEMPERATURE WET TENSILE PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Straight sided tension; ASTM-D3039								Fiber Orientation :	Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)			Batch #3	Task #19				Tested by :	DH
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-44-3	93°C (200°F) (WET)	0.997	0.0707	1,821	25.83	2.797	9,614		3/19/90	(2,3,5,6,7)
BIL-GL-44-6	"	0.999	0.0738	1,887	25.59	2.724	9,897	0.102	"	(2,3,4,6,7)
BIL-GL-44-9	"	0.996	0.0746	1,721	23.16	2.691	9,258		"	(2,3,5,6,7)
BIL-GL-44-12	"	1.000	0.0736	1,830	24.87	2.536	10,034	0.113	"	(2,3,4,6,7)
BIL-GL-44-15	"	0.997	0.0686	1,666	24.37	2.900	8,794		"	(2,3,5,6,7)
			Average		24.76	2.730	9,520	0.108		
			Std. Dev.		1.07	0.135	503	0.008		

Remarks:

(1) Specimen failed within the 6.5 inch gage section.
(2) Specimen failed inside tab area.
(3) Test speed = 0.1 in/min.
(4) Specimen had 0° and 90° strain gages attached.
(5) Specimen had only 0° strain gage attached.
(6) Specimens aged @ 140°F/95-100% R.H. for 42 days.
(7) Average Weight Gain = 2.9160%

SI Conversion			
	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)
	178.1	19.28	9,614
	176.4	18.78	9,897
	159.7	18.56	9,258
	171.5	17.48	10,034
	168.0	20.00	8,794
Average	170.7	18.82	9,520
Std. Dev.	7.4	0.93	503

TABLE Q.4

ROOM TEMPERATURE DRY INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	±45° Tension/Inplane Shear; ASTM-D3518						Fiber Orientation:	±45°			
Material :	EA-9396 A/B; 7781 Glass (A1100-533)			Batch #3	Task #19		Tested By:	DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-46-1	22°C (72°F) (DRY)	0.994	0.0679	1,386	20.52	1.900	10.26	0.622	0.527	2/6/90	(1,2,3,5)
BIL-GL-46-4	"	1.002	0.0705	1,364	19.30	1.784	9.65	0.632	0.412	"	(1,2,3,5)
BIL-GL-46-7	"	1.004	0.0713	1,165	16.28	1.828	8.14	0.621	0.472	"	(1,2,3,5)
BIL-GL-46-10	"	1.004	0.0685	1,305	18.97	2.035	9.49	0.625	0.628	"	(1,2,3,5)
BIL-GL-46-13	"	1.004	0.0669	1,350	20.10	2.125	10.05	0.677	0.570	"	(1,2,3,5)
				Average	19.03	1.934	9.52	0.635	0.522		
				Std. Dev.	1.66	0.143	0.83	0.023	0.084		

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Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
141.5	13.10	70.8	4.290
133.1	12.30	66.5	4.356
112.2	12.60	56.1	4.281
130.8	14.03	65.4	4.310
138.6	14.65	69.3	4.665
Average 131.2	13.34	65.6	4.380
Std. Dev. 11.4	0.98	5.7	0.161

TABLE Q.5

ROOM TEMPERATURE WET INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass (A1100-538) — Batch #3 — Task #19 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-46-2	22°C (72°F) (WET)	1.001	0.0693	928	13.37	1.194	6.69	0.394	0.514	4/24/90	(1,2,3,5,6,7)
BIL-GL-46-5	"	0.999	0.0694	876	12.65	1.180	6.32	0.404	0.459	4/23/90	(1,2,3,5,6)
BIL-GL-46-8	"	1.001	0.0699	861	12.31	1.186	6.16	0.365	0.624	"	(1,2,3,5,6)
BIL-GL-46-11	"	1.002	0.0685	892	12.99	1.323	6.49	0.392	0.687	"	(1,2,3,5,6)
BIL-GL-46-14	"	0.999	0.0677	855	12.64	1.118	6.32	0.335	0.669	"	(1,2,3,5,6)
				Average	12.79	1.200	6.40	0.378	0.591		
				Std. Dev.	0.40	0.075	0.20	0.028	0.100		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight Gain = 2.37% (Only one specimen tracked).

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
92.2	8.23	46.1	2.720
87.2	8.14	43.6	2.789
84.9	8.18	42.4	2.518
89.5	9.12	44.8	2.705
87.2	7.71	43.6	2.308
Average 88.2	8.28	44.1	2.608
Std. Dev. 2.8	0.52	1.4	0.195

TABLE Q.6

ELEVATED TEMPERATURE WET INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test : ±45° Tension/Inplane Shear; ASTM-D3518 — Fiber Orientation: ±45°

Material : EA-9396 A/B; 7781 Glass (A1100-538) — Batch #3 — Task #19 — Tested By: PM

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-46-3	93°C (200°F) (WET)	1.001	0.0706	533	7.54	0.381	3.77	0.117	0.629	4/24/90	(1,2,3,5,6,7)
BIL-GL-46-6	"	0.998	0.0693	453	6.55	0.470	3.27	0.134	0.758	"	(1,2,3,5,6)
BIL-GL-46-9	"	1.005	0.0691	531	7.65	0.536	3.83	0.142	0.893	"	(1,2,3,5,6)
BIL-GL-46-12	"	1.003	0.0667	567	8.48	0.487	4.24	0.124	0.961	"	(1,2,3,5,6)
BIL-GL-46-15	"	1.000	0.0639	456	7.14	0.487	3.57	0.140	0.732	"	(1,2,3,5,6)
				Average	7.47	0.472	3.74	0.131	0.795		
				Std. Dev.	0.71	0.057	0.35	0.011	0.132		

Remarks:

(1) The in-plane shear modulus is calculated using the equation [G=E/2(1+v)].
(2) Specimen had 0° and 90° strain gages attached.
(3) Test speed = 0.1 in/min.
(4) Specimen failed inside the "tab area".
(5) Specimen failed within the 6.5 inch gage section.
(6) Specimens aged @ 140°F/95-100% R.H. to saturation.
(7) Weight Gain = 2.43% (Only one specimen tracked).

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
52.0	2.62	26.0	0.805
45.2	3.24	22.6	0.922
52.8	3.70	26.4	0.976
58.5	3.36	29.2	0.856
49.2	3.36	24.6	0.969
Average 51.5	3.25	25.8	0.906
Std. Dev. 4.9	0.39	2.4	0.074

TABLE Q.7

ROOM TEMPERATURE DRY INTERLAMINAR SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Apparent interlaminar shear	(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)	Batch #3	Task #19	Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	(MPa)	Date Tested	Remarks
BIL-GL-45-1	22°C (72°F) (DRY)	1.000	0.1405	1.141	1,142	6.095	42.02	1/11/90	
BIL-GL-45-4	"	0.999	0.1436	1.141	1,235	6.454	44.50	"	
BIL-GL-45-7	"	1.001	0.1426	1.141	1,150	6.044	41.67	"	
BIL-GL-45-10	"	1.001	0.1425	1.141	1,171	6.158	42.46	"	
BIL-GL-45-13	"	1.001	0.1437	1.141	1,145	5.973	41.18	"	
					Average	6.145	42.37		
					Std. Dev.	0.186	1.28		

TABLE Q.8

ROOM TEMPERATURE WET INTERLAMINAR SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Apparent interlaminar shear	(4pt loading at 1/4 pts. L/D = 8/1)							Specimen Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)	Batch #3	Task #19						Tested By:	DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Weight Gain (%)	Date Tested	Remarks
BIL-GL-45-2	22°C (72°F) (WET)	0.998	0.1407	1.142	794	4.241	29.24	2.69	3/20/90	(1,2)
BIL-GL-45-5	"	1.001	0.1451	1.142	859	4.436	30.58	2.71	"	(1,2)
BIL-GL-45-8	"	1.000	0.1404	1.142	747	3.990	27.51	2.62	"	(1,2)
BIL-GL-45-11	"	1.001	0.1434	1.142	846	4.420	30.48	2.70	"	(1,2)
BIL-GL-45-14	"	1.000	0.1433	1.142	805	4.213	29.05	2.73	"	(1,2)
					Average	4.260	29.37	2.69		
					Std. Dev.	0.182	1.25	0.04		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. for 68 days.

(2) Average Weight Gain = 2.69%

TABLE Q.9

ELEVATED TEMPERATURE WET INTERLAMINAR SHEAR PROPERTIES OF
EA9396 LAMINATES REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :	Apparent interlaminar shear	(4pt loading at 1/4 pts. L/D = 8/1)							Specimen Orientation:	Warp
Material :	EA-9396 A/B; 7781 Glass (A1100-538)	Batch #3	Task #19						Tested By:	DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Weight Gain (%)	Date Tested	Remarks
BIL-GL-45-3	93°C (200°F) (WET)	1.001	0.1425	1.142	343	1.803	12.43	2.72	3/21/90	(1,2)
BIL-GL-45-6	"	1.001	0.1452	1.142	346	1.785	12.31	2.67	"	(1,2)
BIL-GL-45-9	"	1.000	0.1398	1.142	350	1.878	12.95	2.63	"	(1,2)
BIL-GL-45-12	"	1.000	0.1439	1.142	355	1.850	12.76	2.70	"	(1,2)
BIL-GL-45-15	"	0.998	0.1437	1.142	356	1.862	12.84	2.67	"	(1,2)
					Average	1.836	12.66	2.68		
					Std. Dev.	0.039	0.27	0.03		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. for 68 days.

(2) Average Weight Gain = 2.68%

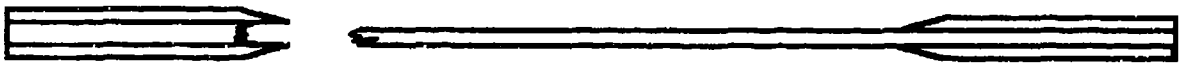


Figure Q.1. Failure Location of Tensile Specimens That Failed Inside Tab Area.

APPENDIX R
DETERMINATION OF BLEEDER ABSORPTIVITY

The bleeder materials used in this program may not be available when performing a repair. If an alternative bleeder material is used, its absorptivity can be determined by the procedure outlined below. It is suggested that absorptivity be determined by this procedure for several bleeder/laminate ply ratios that bracket the layup actually used so that a reliable average value can be determined. The primary reason that bleeder absorptivity is of interest is to provide guidance in selecting a bleeder/laminate ply ratio that will produce the desired final resin content. It must be recognized, however, that not all resin is removed by the bleeder. Some will be lost around the edges of the layup. Additionally, the amount absorbed by the bleeder will probably vary if the amount of excess resin used in the laminate layup or the bleeder/laminate ply ratio varies significantly from those used in the absorptivity determination.

1. Select Bleeder/Laminate ply ratio.
2. Bleeder plies are to be same size as laminate plies, and should be both weighed and measured (length x width) prior to layup.
3. Compute area density (gm/m^2) of dry bleeder material

$$\frac{\text{wt. of DBPS}}{\text{area of DBPS x no. of plies in DBPS}} = \text{area density of DBP}(gm/m^2)$$

where DBPS = dry bleeder ply stack.

4. Layup and impregnate laminate plies in accordance with standard procedure described in Appendix A (except for bleeder ply differences if using other than Mochburg CW 1850).
5. Bag and cure in accordance with the standard procedure described in Appendix A.
6. After cure, dismantle the bagged layup and separate the impregnated stack of bleeder plies from the nonporous teflon/glass and the porous teflon/glass sheets.
7. Weigh and remeasure the impregnated bleeder stack.
8. Compute amount of resin absorbed in each unit area of bleeder

$$\frac{\text{wt. of IBS}}{\text{area of IBS x no. of plies in IBS}} = \text{area density of IBS}(gm/m^2)$$

where IBS = impregnated bleeder stack.

$$\frac{\text{area density of IBS - area density of DBPS}}{\text{no. of plies in IBS}} = \text{area density of resin in bleeder , or absorptivity } (\text{gm} / \text{m}^2)$$

9. Compute amount of resin absorbed in each unit weight of bleeder

$$\frac{\text{wt. of IBS - wt. of DBPS}}{\text{wt. of DBPS}} = \text{absorptivity (gm resin / gm bleeder)}$$

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